R&D AND PRIVATE CORPORATE PERFORMANCE: AN ECONOMETRIC STUDY OF THE INDIAN MANUFACTURING SECTOR

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CERTIFICATE

This is to certify that the thesis **"R&D AND PRIVATE CORPORATE PERFORMANCE: AN ECONOMETRIC STUDY OF THE INDIAN MANUFACTURING SECTOR"** submitted by Mr. Dwarika Nath Mishra in partial fulfillment of the degree of Doctor of Philosophy to the Indian Institute of Technology, Kanpur, is a record of bonafide research work carried out under our supervision and guidance. The results embodied in the thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

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SYNOPSIS

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A Thesis Submitted in Partial Fulfilment of the Degree of PhD
By
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Under the Supervision of
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It is commonly understood that industrial units undertake research and development (R&D) activities to continuously develop new products or processes of production to remain competitive in the market. The Indian economy prior to 1991 was essentially a protected one. The essence of the industrial and technological policies were webbed mainly to adapt, absorb, and assimilate imported technology for generic use and encourage domestic producers through a number of tax rebates and liberal subsidies and other indirect benefits, to set up their own in-house R&D laboratories and substitute the imported capital goods and raw materials by the indigenously available resources. The Indian industry was not truly competitive and therefore was not in a pressure to innovate. Moreover, the Patent Act of 1970 provided a liberal and weak patent regime, which did not protect the inventive efforts of the domestic innovators adequately.

After the 'liberalisation' of the economy ushered by the New Industrial Policy of 1991, the need for innovations and efficient technological processes is being increasingly felt by the Indian industry. The catchword in the new globalised economy of today is 'innovate and adapt or perish'. The new patent regime, which protects the innovators but severely restricts the Indian industries age long tradition of copying products and designs from abroad. New technologies would have to be bought at a price. Further, it must be recognized that decent foreign technologies are very expensive and also the latest technologies are not generally available for import; what is normally available is a relatively older technology. Moreover, the access to the state of the art technology from developed countries enables a firm to enter into a new market and gains temporarily. To sustain the gain a firm will have to unbundle, adapt, assimilate and absorb the acquired technology for continuous improvement in the product and reduction in the cost. In such a scenario the Indian industrial units are required to invest heavily in R&D to survive and compete.

The present study is an attempt to examine the R&D behaviour of Indian private corporate firms of highly technologically intensive industries (electrical equipment, machinery, pharmaceuticals, chemicals, chemical products, and automobile). In particular the thesis addresses the following aspects:

- Effect of Internal finance on in-house R&D,
- Effect of R&D on ensuing profitability
- Effect of R&D on the subsequent exporting
- Effect of other factors on R&D, profitability and exporting

These relations are investigated for the groups of local enterprises (LCEs) and the multinational affiliates (MNEs) separately[1].

The internal finance is measured by two variables - the retained earnings (profit-after-tax less dividend paid) and cumulative depreciation and depletion charges. The profitability is measured as (Revenue - Costs - Depreciation charges - Interest charges). The exporting is measured through the earnings by firms in foreign currencies (which are converted into the domestic currency according to the prevailing exchange rates). The in-house R&D effort of the firms is measured by R&D expenditure. The advertising and marketing efforts by the firms are measured by the expenditures incurred on these activities. The measure of imported capital goods includes the expenses on imported capital goods and stores and spares. Technology import includes technical fees, better known as lump sum payments, royalties, consultancy and professional fees. The capital investment is taken as the net addition to the physical capital. The debt- equity ratio is used as a proxy for external sources of funds. The growth rate of sales is used as a reflection of market demand conditions. All of the variables except ratios are deflated by firm size variable. The firm sale (net of 'rebates and discounts' and 'excise duty and cess) is taken as a measure of firm size or size deflator. The import pressure felt by a firm is calculated as:

$$IP_{ijt} = \mathrm{Im}port_{jt} \times \frac{DMS_{ijt}}{(AS_{jt} - A\exp ort_{jt})}$$

where,

IP_{ijt} : Import pressure felt by i[th] firm in j[th] industry in time period t,

$\mathrm{Im}port_{jt}$: Aggregate import by j[th] industry in period t;

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[1] In tune with Reserve Bank of India' definition of Foreign Controlled Rupee Company, by MNEs, we refer to those Indian affiliates of western multinational enterprises in which they retain at least 25 per cent of the foreign equity ownership.

DMS_{ijt} : Domestic market share of i^{th} firm in j^{th} industry in period t;

AS_{jt} : Aggregate sales of the j^{th} industry in period t and

$Aexport_{jt}$: Aggregate exports of the j^{th} industry in period t.

The study employs a balanced panel of 282 firms for a period covering five years 1991-1995[2]. A pooled-cross-section approach and the least square dummy variable (LSDV) models has been used to estimate the regression coefficients for each of the industries /groups.

The major findings of the study are summarised as follows:

In some of the industries (such as machinery, pharmaceutical and automobile) retained earnings provides significant explanation for subsequent R&D intensity for the MNEs. This relationship is also found to hold for the LCEs in the chemical industry. The prior cumulative depreciation reserves positively affect R&D intensity in automobile industry for the MNEs and in machinery and chemical industries for the LCEs. The prior debt-equity ratio is found to be negatively associated with R&D intensity for the LCEs in the pharmaceutical, chemical and chemical products industries. It has similar effect in case of electrical, automobile, machinery industries for the MNEs. On other hand, debt-equity ratio is positively associated with subsequent R&D efforts in electrical industry for the LCEs and in pharmaceutical and chemical industries for the MNEs.

In some of the industries (machinery and pharmaceutical) R&D intensity positively and significantly explains the profitability of LCEs. The same is true for MNEs in the chemical industry. Prior technology import intensity influences

[2] The distribution of sample along industries and groups are as follows: Electrical equipment (42 LCES and 9 MNEs), Macinery (48 LCEs and 13 MNEs), Pharmaceuticals (31 LCEs and 15 MNEs), Chemicals (29 LCEs and 9 MNEs), Chemical products (31 LCEs and 15 MNEs) and Automobile (35 LCEs and 7 MNEs).

profitability of the LCEs positively only in the automobile industry. It has similar effect for the MNEs in the pharmaceutical industry.

Prior R&D intensity provides an important explanation for export intensity in pharmaceutical industry for both LCEs and MNEs. It is also important for LCEs in chemical and automobile industries and for MNEs in chemical products industry. Technology import is important for LCEs in chemical and machinery industries. For MNEs it is found to be positively significant in chemical products industry.

In most of the industries profitability is found to increase with firm size and decrease with its square term. In contrast, R&D decreases with firm size and increases with its non-linear term. It is the big firms that are able to export. In most of the industries profitability increases while R&D decreased with sales growth.

With few exceptions, import pressure adversely affects price-cost margins of the firms, which in turn compels firms to invest in R&D to counter the threats arising from imports.

Technology imports shows positive association with R&D for LCEs in the pharmaceutical industry and for MNEs in the chemical products industry. It is negatively related to R&D in the chemical products and automobile industries for MNEs.

The main conclusion that emerges from the present study is that, in general, firm level determinants of R&D, profitability and exporting varied across different industries and groups. While sources of internal finance are crucial for R&D investment by the LCEs, these are not binding for the R&D efforts of the MNEs. For the LCEs, the R&D efforts add to their profitability

and exporting. Despite higher R&D investment by MNEs, it does not have any influence on their profitability and exporting except in hazardous industries like chemical and chemical products. It seems that the benefits generated by their R&D efforts are translated to their parent organizations rather than employed for their Indian operations.

DEDICATED TO

MY

TEACHERS

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CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

The role of technological innovations in economics has received increasing attention in the past few years. Though the writings of classical economists, from Adam Smith to Alfred Marshal, recognized the importance of innovation in products and in methods of products as a source of economic progress, they did not see them as an integral part of the economic production itself but as originating outside the economists' framework of analysis. Even Karl Marx, who argued that transformations in the structure of production determined all changes in social relationships, had nothing to say about the origins of such transformations. Their viewpoints may be justified on the two grounds: firstly, technology appeared as customary practice, which did not change much over the time, and secondly, technology was next in importance to science (Spencer, 1970).

Veblen (1904,1921) was the first economist who recognized technology as an integral part of economic production system. According to him technology was not an exogenous force, for businessmen, managers, and workers, but rather a set of material and social relationships shaped by them and at the same time shaping their behavior and their values. However, the black box characterization of technology was really shed with the writings of Schumpeter (1943,1950). He considered "innovation "as the engine of development in the capitalist economy. As he says:

"The fundamental impulse that sets and keeps the capitalists engine in motion comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates"(1950, PP 83).

Innovations can take various forms such as the introduction of a new good or a new quality of good, the introduction of a new method of production, the opening of a new market, the conquest of a new source of supply of raw materials, and the designing of the new organization or any industry (Schumpeter, 1943). The first two- technological innovations - got most attraction. He considered continuous occurrence of innovations, as the basic trait of the capitalistic economy. Profit seeking entrepreneurs try to increase profits by introducing new goods and production methods in response to changes in both demand and production possibilities. The result of these activities, according to Schumpeter, is not just a disturbance of prevailing economic conditions, but a process of creative destruction, which devalues existing market positions of the firms and their stock of capital. Eventually the competition leads to the spread of the new combinations and the profits reaped by the pioneers gets eroded. The economy reaches to a new equilibrium state- inviting new creative destruction.

The post world war II saw a distinct phase in the technological developments. The factors such as high capital requirements and inherent economies of scale involved in the modern science based applied research, growing power of corporations over resources and markets, and increasing reluctance of financiers to stake inventor-entrepreneurs to the capital necessary for the development of their ideas led most successful innovations in the well established organizations (Rosegger, 1986). The increasing competition and shortening product horizon over the past few decades has led business firms to adopt technology as an important devise to move ahead vis-a-vis their competitors. In fact it has also proved essential for their long run survival. The firms invest significantly in formal research and development

(R&D) to achieve higher growth and profitability[1]. Today in the age of globalization and increasing technological inter-dependencies among various economies and firms the importance of in-house R&D activity of firms has increased manifold. The objective of R&D is no longer restricted to the generation of new products and processes. It has also become a potent mechanism for firms to assimilate and exploit technological developments elsewhere. The R&D is also employed to diversify the activities of the firm over a number of products so that the fluctuations in the economic performance of the firm can be minimized. Sometimes R&D is effectively used to retain core competencies. And sometimes R&D is applied merely to differentiate the existing products

The discussion in the rest of the chapter is as follows: The status and patterns of R&D expenditures in India is summarized in the section 2. Section 3 maps R&D environment of India. The objectives of the study are discussed in section 4. The chapter will conclude with a plan of the present study in section 5.

1.2 R&D PATTERNS IN INDIA

Developed economies devote a significant share of their income and labor force to basic and applied research and product development, both within non-profit institutions (universities, government laboratories, etc.) and profit seeking firms[2]. On the contrary, developing countries like India despite having the distinction of being the fifth largest in terms of technical manpower, spends very little on R&D, both in non-profit and profit making organizations. The share of the less developed countries (LDCs) in world R&D is only 5%. Moreover, R&D investment as a percentage of gross national product (GNP)

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[1] In-house R&D is the research and development carried out by an industrial unit within its boundary to develop some new or/and improved product or process of production and also to meet the technical and technological requirements of its manufacturing activities such as design engineering and analysis.

[2] “Basic research” corresponds to the activities aimed at the original investigation for the enhancement of scientific knowledge. “Applied research” involves the search for the commercial application of the scientific knowledge generated out of the basic research; and

for the developing countries is also very small. For instance, in 1997 developing countries invested only 0.65 % of their aggregate GNP in R&D as against 2.92 % by the developed countries[3]. India's spending on R&D as a percentage of its GNP, is approximately 0.91%. In fact India's R&D expenditure is about 1% of R&D in the USA and 2% of that in Japan[4]. Further in developed countries, the R&D spending by industrial sector is more than the non-profit institutions. In some developed countries, the percentage share of R&D spending by the industry is in the range of 45-80%, while in a developing country like India the share of industry in total R&D spending is only 26%. Moreover, Indian industry R&D spending as a percentage of its total turnover is only 0.6%[5]. On the contrary, the firms in the USA spend 5-20% of their sales turnover on R&D. Furthermore, the contribution of the Indian private corporate sector in basic research is almost nil as against 20% of their US counterparts.

1.3 R&D ENVIRONMENT OF INDIA

The Indian industrial and technological policies clearly depict two distinct paradigms. Prior to 1991, Indian government's industrial policy regime was webbed mainly around heavy licensing, high regulatory norms and restrictive imports. Foreign direct investment was equally discouraged. Virtually, all the producers of manufacturing commodities were required to serve the domestic market under the protection of high tariff wall. The technological collaborations with foreign multinational enterprises (MNEs) were highly regulated, scrutinized and restricted. The MNE activities were regulated and discouraged even more. The policy regarding the technological development was mainly aimed at setting up a number of research laboratories across the country /industries and favoring technology import from abroad in select areas of high technology. In fact, the essence of the technology policy was adaptation, absorption, and assimilation of imported technology for generic use. The

domestic producers were encouraged through a number of tax rebates and liberal subsidies and other indirect benefits, to set up their own in-house R&D laboratories, mainly, to substitute the imported capital goods and raw materials by the indigenously available resources. Undoubtedly, all these policies led to major strides in achieving self-reliance in terms of increased domestic production of import substitutes of a wide variety but only at the cost of overall technological stagnation in the manufacturing sector. Uncompetitive and rigid production structure did not provide sufficient incentives to Indian producers to innovate and adopt better technologies or translate their internal technological capability into new and improved processes and products (Subramanium, 1985). Moreover, the Patent Act of 1970 provided a liberal and weak patent regime, which did not protect the inventive efforts of the domestic innovators adequately.

The Industrial Policy Statement of 1980 and Scientific Policy Resolution of 1983 gave some emphasis on liberal industrial and technology policies. However, in actual practice the preceding policy measures continued except for a few changes made in respect of entry, diversification, capacity expansion, foreign collaboration, import of machinery and components and few more provisions for setting up in-house R&D units by firms. However, with the implementation of liberal and market oriented economic policies as outlined in the New Industrial Policy of 1991 and the New Technology Policy of 1993, the dimension of indigenous technology development and scientific research has undergone a drastic change. The changed economic policy environment gives much freedom to producers for import technology or technological collaborations with foreign producers. It also encourages foreign direct investment though with some restrictions.

Despite liberal licensing policy for the import of technologies in a number of areas, it must be recognized that decent foreign technologies are very expensive and also the latest technologies are not generally available for import; what is normally available is a relatively older technology. Moreover, the access to the state of the art technology from developed countries enables a firm to enter into a new market and gains temporarily. To sustain

the gain, a firm will have to unbundle, adapt, assimilate and absorb the acquired technology for continuous improvement in the product and reduction in the cost (Evenson and Westpal, 1994). Therefore, the need for indigenous development of innovative technologies remains very strong. The recent changes in the international policies and programs such as creation of World Trade Organization (WTO), new Intellectual Property Rights (IPR) system, among others, would also have a significant bearing on the domestic technology development.

Nevertheless, the availability of a large number of qualified and technically trained manpower and lower costs of doing research in India may provide her with a strong competitive position on the global R&D platform. The high quality science base prevalent in India in certain select areas is also a big attraction, especially when one recognizes that industrial R&D is increasingly becoming science based. Also, the companies perceive that collaborations with scientific research institutes may provide mutants of an existing technology that is fully adaptable to the existing conditions prevailing in India. Thus the post liberalization environment poses not only a challenge but also offers excellent opportunities, such as improved freedom and flexibility, better communication and IPR protection, improved consciousness about quality and time of delivery, etc., to the industrial firms to invest in R&D and compete with their rivals, especially, multinationals in both domestic and global markets.

1.4 OBJECTIVES OF THE STUDY

As outlined in the preceding section the new policy environment has not only made the supply of technology flexible but it also demands increasing R&D efforts by the firms. In this context, it becomes imperative to study the various aspects of R&D behavior of the firms. An important question in any study of the R&D behavior of firms concerns its mode of financing. Since (Schumpeter 1950), the availability of internal finance generated by their existing operations rather than external resources is regarded as the easiest and most effective way to finance additional investment in the R&D activities

by the firms. This is because of the problems like moral hazard and adverse selection that hinder external financing of highly risky and uncertain activities like technological innovations (e.g., Arrow 1962). The absence of collateral value for investments like R&D aggravates the problem of adverse incentive and selection. Some empiricists also ventured to test such hypothesis in developed countries [e.g., Scherer (1965b), Mueller (1967), Grabowski (1968), Grabowski and Mueller (1972), Branch (1974), Himmelberg and Petersen (1994), among others]. There is no study for a developing country like India except Kumar and Saqib (1996).

An equally important question in any study of the R&D behavior of the firms is related to its impact on their economic efficiency measured through profitability[6]. The technological activities can influence the economic performance and hence economic efficiency of firms by shifting their demand curves to the right through the introduction of new or improved products. R&D can also affect the efficiency by reducing the cost of production of a firm through new or improved process innovations or changes in the input-mix to suit the local resource endowments and environment, or a combination of some or all of these. Several studies attempted to examine the impact of R&D activity of firms on their profits [e.g., Scherer (1965a), Branch (1974), Grabowski and Mueller (1978), Geroski et. al (1993)] in case of developed countries. Siddharthan and Dasgupta (1983) and Kumar (1994) also examined such relationship for Indian manufacturing sector.

Another important question concerns the relationship between R&D efforts and subsequent exporting at the firm level. In an open economy competitiveness of a country is seen by its exporting level, which in turn depends upon its technological capability. A similar conclusion should also emerge at the firm level, simply because technological knowledge is embodied in firms. It is at the firm level where decisions are taken regarding commitment of resources to innovative activities and the benefits of innovations are enjoyed, either in terms of cost reductions or creation of new

[6] The economic performance can also be approximated in terms of productivity growth or sales growth, or market share or rate of return (ROR) on investment or net worth.

or improved products. The aggregated benefits and competitiveness of firms are translated into the competitiveness of a country. Further even if the country as a whole is not competitive, a firm may be expected to be competitive in terms of exporting because of its own innovative activities. Some studies investigated the relationship between R&D investment and exporting at firm level for the developed countries. Important studies include Hirch and Bijaoui (1985), Ito and Pucik (1993), Becchetti and Rossi (1998) and Wakelin (1997; 1998), among others. A handful of studies such as Dasgupta and Siddharthan (1985), Lall (1986), Kumar (1990) and Kumar and Siddharthan (1994) have also analyzed such relationships for the developing countries like India.

Most of the studies investing either R&D financing, or impact of R&D on profitability or exporting are subject to several limitations. Firstly, these studies examined contemporaneous relationship between concerned variables for a single year or for an average of several years. Secondly, they investigated either inter-industry variation or inter-firm variation across the industries. Moreover Indian studies belong to the pre-liberalization era. Therefore it would be worthwhile to examine and quantitatively estimate the inter-firm variation in the impact of internal finance on subsequent R&D and ensuing influence of R&D on the profitability and exporting of firms in the post-liberalized India.

In addition to internal finance, the R&D activities of the firms also depend on several other factors. Similarly R&D activity alone is not sufficient to boost the profitability or exporting of the firms. For instance, the possession of complementary assets such as, marketing channels, manufacturing capability, brand image and market power, etc., by a firm also plays an important role in capturing profits out of its technological innovations [Teece 1986]. In general the R&D, profitability and exporting of firms also depend on a host of other factors such as firm size, capital investment, technology imports, capital goods import, advertising and selling activities, etc. Some of these factors may be common to all of the dependent variables while others may be specific to only one.

Further an industry may consist of groups of firms, each group composed of firms that are quite similar to one another along the structural dimensions such as - degree of vertical integration or diversification, advertisement intensity, brand establishment, captive distribution channels, line of selling (full or narrow), and market spread, skill and technology intensity etc (Caves and Porter, 1977). The strategic differences between firms are, among other things, reflections of their tangible and intangible assets (Porter, 1979). In these respects western multinationals enterprises (MNEs)[7] are clearly stands out to be very different from the local enterprises (LCEs). Being part of global enterprises, MNEs enjoy persistent advantages over their local counterparts in respect of technological strength and learning, reputation, width of product range, and associated services. Thus it seems logical to investigate the determinants of R&D, profits and exporting for MNEs and LCEs separately to estimate possible differences between them.

1.5 CONCLUDING REMARKS

The Indian industrial and technology policies clearly reflect two distinct paradigms. Prior to 1991, the process of industrial and technological transformation was mainly concentrated on supply side aspects and the needed emphasis on the demand side aspects of technological transformation was largely ignored. After the 'liberalization' of the economy ushered by the New Industrial Policy of 1991, and the New Technology Policy of 1993, the need for innovations and efficient technological processes is being increasingly felt by the Indian industry. Moreover the emergence of a new economic world order under WTO with strong emphasis on the global economic structure and protection of intellectual property rights would also have a significant bearing on the domestic competitive environment and technology development.

[7] In tune with Reserve Bank of India' definition of Foreign Controlled Rupee Company, by MNEs, we refer to those Indian affiliates of western multinational enterprises in which they retain at least 25 percent of the foreign equity ownership.

In light of these changes in the competitive environment of the Indian economy and particularly new paradigmatic changes in the Indian industrial sector, it is worthwhile to examine the R&D behavior of firms for the leading R&D intensive industries. Specifically, the underlying study seeks to provide quantitative estimates of the following:

- Impact of Internal finance on subsequent R&D
- Impact of R&D on subsequent profitability
- Impact of R&D on subsequent exporting
- Impact of other factors on R&D, profitability and exporting
- All the above for LCEs and MNEs

The rest of the thesis is organized as follows: The theoretical and empirical literature concerning internal finance and R&D is discussed in chapter 2. The chapter 3 is devoted to the literature related to R&D and profitability. The chapter 4 discusses R&D and exporting at the firm level. Chapter 5 maps out data description and measurement of variables. The econometric framework of the study is described in the chapter 6. Regression results for internal finance and R&D are reported to the chapter 7. The following two chapters describe the regression results for R&D and profitability, and R&D and exporting, respectively. The summary and conclusion of the study will be presented in chapter 10.

CHAPTER 2

IN-HOUSE R&D AND INTERNAL FINANCE

2.1 INTRODUCTION

An important impediment associated with any research and development (R&D) investment is financial barrier. The R&D financing can take place either through internally available resources or through externally generated finances. Since Schumpeter (1950, Chap VIII, P.87) profits and its association with the availability of internal finance has been regarded as the easiest and most effective way to finance additional investment, especially the investment in the R&D activities of firms. Levin (1978) argued that by financing R&D out of quasi-rents earned on their superior technology, existing firms generate further technical progress, which continuously recreates their cost advantage over potential entrants. In fact one of the common and prominent characteristics associated with industrial R&D is the virtual necessity for it to be financed internally from a firm's current profits and accumulated funds (Kamien and Schwartz, 1982). These views entail that a firm must generate enough internal resources from its existing operations to finance the future investments in R&D.

On the other hand, the problems of moral hazard and adverse selection hinder external financing of highly risky activities like technological innovation (Arrow, 1962). Grabowski (1968) provided some early cross-sectional support for the internal financing view of the R&D, while Mueller (1967) and Hamberg (1966) did not find such an effect. The models, developed by Stiglitz and Weiss (1981) and Myers and Majluf (1984), among others, of moral hazard and adverse selection in debt and equity market, which are equally applicable to R&D investments, give a formal justification for

internal financing of R&D investment. The absence of collateral value for intangible investments like R&D aggravates the problem of adverse incentive and selection.

The rest of the chapter is structured into four sections. The section 2 provides theoretical support in favour of internal financing of R&D investment. In the second section empirical literature is reviewed. The section 3 presents the relevance of internal financing hypothesis in Indian context. The fourth section describes a host of other possible factors that are also likely to determine In-house R&D investment of firms.

2.2 THEORY

In the corporate finance literature various theories are developed and different reasons are cited in favour of internal sources of finance (such as retained earnings and depreciation reserves) rather than external sources (such as new equity issues and new debt issues) as a less costly source to finance additional investment (especially R&D). Important among them are as follows:

2.2.1 Transaction Costs

The transaction costs related to seasoned equities are costly (Fazzari et al, 1988). As in the US, Indian underwriters purchase a block of new shares and resell it. Relative to gross proceeds, the cost of new share issue, including underwriting discounts, registration fees and taxes, and selling and administrative expenses might vary substantially by size of offering, the cost of small offering can be high. This implies that equity finance, as a source of additional R&D investment is costlier.

2.2.2 Tax Structure

The corporate tax structure in India (and in many other countries especially, developed ones) has provided a cost advantage to internal equity finance over external equity finance. In India, the effective tax rate on capital

gains has been much lower than the tax rate on dividends. The gap between capital gains and dividend tax rates has also widened during 1990s. This differential gives a cost advantage to internal finance. While no tax saving is imparted from the issue of new shares, tax savings do accrue when earnings are retained rather than paid out, because a dividend tax is replaced with a lower tax on capital gains (Fazzari et al, 1988).

2.2.3 Asymmetry of Information

The problems of imperfect information and incomplete contracting in the equity and debt markets can generate potentially significant cost disadvantages of external finance for an additional R&D investment by the firms. The R&D projects suffer from the stock market myopia, implying a state of market failure to value long-term projects properly. The investors have more difficulty distinguishing good projects from bad, especially when the projects are long -term R&D investments (Leland and Pyle, 1977). They value them all at the population average. Due to an inherent moral hazard problem, it would be difficult for a firm (entrepreneur) to reveal the information about a risky project and convince investors the benefits of the risky and long-term ventures. Firms do not like to reveal their innovation ideas to the market place and this fact reduces the quality of the signal they can make about the project; there is a cost to revealing information to their competitors [Bhattacharya and Ritter (1983)]. Consequently, new investors implicitly demand a premium to purchase the shares of relatively good firms to offset the losses that will arise from funding lemons. In other words, the lemon's premia signaling the equity market would be higher for the R&D projects. This premium can raise the cost of new equity finance faced by the managers of relatively high-quality firms above the opportunity cost of internal finance faced by existing share holders [Akerlof (1970), Myers and Majluf (1984)].

Myers and Majluf (1984) formally modelled the problems of adverse selection arising as a consequence of the asymmetric information in the equity market. They postulated that managers, who act in favour of existing shareholders, have superior information about true value of firm's investment

opportunities (and other assets) than the market. Market being unaware of the future prospects of investment undervalues firm's common stock shares. Managers who wish to maximize the wealth of existing shareholders will not issue new shares to finance additional investment even if it is meant to forgo the investment projects with positive net present values unless they have sufficient internal cash flow to undertake them. The model also shows that debt financing is better than financing by equity. Thakor (1993) surveyed the empirical evidences in support of such arguments. In a recent study, Minton and Schrand (1999) found an empirical support that higher cash flow volatility is associated with lower average levels of investment, especially R&D, implying that firms do not use external capital markets to fully cover cash flow shortfalls but rather permanently forgo investment. Cash flow volatility is also associated with higher costs of accessing external capital. Moreover, these higher costs, as measured by some proxies, imply a greater sensitivity of investment to cash flow volatility.

Myers and Majluf (1984) and Myers (1984) *inter alia*, suggested a financial "pecking order" model. The internal cash flow is the cheapest source to finance additional investment. Once internal cash flow is exhausted, the firm should borrow to satisfy its capital need. The new equity issue, which is the most expensive, should be taken as the last resort to finance additional investment. This pecking order model recognizes both asymmetry information and costs of financial distress. The firm faces two increasing costs as it climbs up the pecking order. It faces higher odds of incurring costs of financial distress, and also higher odds that future positive net present value (NPV) projects will be passed because the firm will be unwilling to finance them by issuing common stock or risky securities. Thus the conclusion of these stories is that the positive shocks to cash flow will lead to more investment in such a situation. These arguments that are basically developed for the capital investment, seems to be more relevant for R&D projects where information asymmetry is compounded.

2.2.4 Lemon Problems in Debt Market

As cited above, because of the fear that knowledge may leak out to its competitors, a firm is unlikely to reveal content and objectives of its R&D efforts[1]. Strategic considerations of this kind will tend to maintain and reinforce informational asymmetries between the firm (borrower) and the lenders. But even without secrecy undermining the incentives to share information about R&D projects, the evaluation of long-term risky projects by external financiers may be more costly than the assessment of more short-term oriented ones. Moreover, the monitoring by the lenders that borrowing firm should stick to the originally devised projects may not be without cost. Thus, if lenders face greater uncertainty with respect to R&D projects, they will require a higher lemon's premium for such type of investment. This implies that the shadow cost of R&D financing through debt is more than the cost of internal financing.

2.2.5 Credit Rationing

The problem of asymmetric information may also result in credit rationing by the lenders. A host of theoretical papers [See, for example, Jaffee and Russel (1976) and Stilitz and Weiss (1981), Bester and Hellwig (1987), among others] concerns the asymmetric information between borrower and lender as a possible cause for resorting to credit rationing by the lenders. Due to the asymmetric information, the lenders cannot distinguish between the good quality loans with the bad quality. In equilibrium this gives rise to the problem of adverse selection. As the loan size is limited, when the interest rates rise, the relatively safe investors drop out of the market and other borrowers are tempted to undertake riskier projects. This increases the probability of default and reduces the lenders expected profits. To overcome the problem, lenders may set an interest rate that leaves an excess demand for loans in the market. Some borrowers receive loans while others are rationed even if they offer a higher interest rate than is observed in the market

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[1] See Mansfield (1985) for some evidence on the speed of information dissemination. Theoretical models of knowledge dissemination are presented by Bhattacharya and Ritter (1985) and Bhattacharya and Chiesa (1994).

for loans (Stiglitz and Weiss, 1981). The implication of credit rationing theory is that debt is not always available to the firm for R&D projects.

2.2.6 Managerial Discretion

The managerial discretion theory which have mainly been drawn from Marris' (1964) growth maximisation theory, argue that it is not so much that external sources of funds are expensive in the sense of the firm's high transaction costs or harming its shareholders by raising it, but the internal fund is cheap and provides much flexibility to management to undertake growth oriented investments (e.g., investments in R&D) even if the expected rate of return is lower than the shareholders' opportunity costs [Grabowski and Mueller (1972) and Kathuria and Mueller (1995)].

2.2.7 Collaterlization Problems

The investments in intangible assets like R&D are presumably more risky and provide less collateral to lenders. Banks prefer to use physical assets to secure loans and are reluctant to lend when the project involves substantial R&D investment. This is because redeployable assets as collateral for the debt are more suitable to the governance structure of the banks /financial institutions. R&D results such as a new prototype or a design cannot be used easily as collateral. The investment share of R&D expenditures is insignificant. A major portion of total expenditures of any R&D project is spent in the form of wages and salaries to the scientific and skilled personnel [Hall (1992) and Harhoff (1998)]. Moreover, most investment inputs to the innovation process are likely to be firm-specific or specific to the new product or process to be developed. As a consequence, an external financier cannot expect to recover a significant share of her funds if it is used to finance an unsuccessfull innovation project. Thus collateralization problem hinders lenders in extending loans to firms for R&D projects.

2.2.8 Financial Distress

Deadweight financial distress costs may be there in case of debt finance of R&D projects. Standard theories related to the effects of leverage

on the firm's cost of funds posit an increasing marginal cost of financial distress. Financial distress costs arise when a firm has difficulties meeting its principal and interest obligations. In extreme case financial distress costs include the legal and administrative costs of bankruptcy. Moreover, there may be the subtler agency, moral hazard, monitoring and contracting costs, which can erode firm value even if formal default is avoided. Specialised assets (like R&D) or growth opportunities are more likely to lose value in financial distress.

While the gains of a successful R&D project goes to the pockets of the stockholders, managers have to face the onslaught of the costs of bankruptcy. Managers are more risk averse than stockholders and hence wish to avoid risky R&D projects if it increases the riskiness of the firm. If financial distress or bankruptcy is a possibility, managers whose opportunity cost are lower than their present earnings and hence wish to avoid variance- increasing projects which shareholders may like to undertake.

2.2.9 Agency Problems

Debt finance creates agency problems. Agency problems arise from incompleteness of the debt contracts (contractual agreements to control all aspects of borrower behaviour are infeasible) that create incentive for the firm managers to counter to the interests of creditors under some circumstances. The greater the debt-equity ratio, more the incentives for the managers who act in the interests of the equity holders diverge from the interests of creditors. They have the incentives to issue new debt that raises the riskiness and lowers the value of the existing debt. Because creditors anticipate the conflicts of the interest that exist between themselves and stockholders, they demand covenants that restrict the behaviour of mangers, particularly with respect to new debt issues. As a result, covenants typically stipulate target debt-equity ratios. While they provide a second best solution to the contracting problem given the potential for opportunism, they are not costless, and their restrictions on financial flexibility limit management's choices of investment opportunities when internal funds are low. If covenants impose working capital requirements, the supply of internal funds available to finance investment may

be reduced. Hence shocks to working capital, such as a debt deflation or a decline in internal finance, will make debt finance more expensive at margin, probably at a time when the need for debt is more acute (Fazzari et al 1988).

Together the above arguments suggest an important role for internal finance, independent of their value as a signal for the future profitability, in determining the level of R&D investment of the firms. At the same time the shadow costs of external financing (such as equity and debt) of R&D projects are higher than the internal financing. The critics however point out two things:

(1) In addition to providing a possible source of funds for R&D projects, profits may be related to the shocks, which imply increased profit opportunities in the future, and there with R&D investment, which increases in response to this expectation. Thus this can too lead to the substantial positive correlation between profit rates and changes in the observed R&D investment. This raises the question that whether the connection between internal cash flow and R&D investment is caused by credit constraints or by changes in expectations (Hall, 1992). Gilchrist and Himmelberg (1994) however showed that even after controlling for the expected future marginal profitability (fundamental determinants as they termed it) content of the cash flow-flow variable, it appeared positively significant in explaining the variation in the investments. Further, the present study takes into account accounting retained earnings, and not the market value, which is likely to contain information about the future profitability.

(2) The adjustment costs of R&D projects are very high [Himmelberg and Peterson (1994) and Harhoff (1998)]. The R&D process cannot be ayed or accelerated costlessly. Scientists cannot be fired and rehired ıout substantial loss of human capital to the firm (and potential gains to npetitors), and due to their high degree of specialization, resources ployed in R&D cannot simply be used in production (or vice versa). Thus, adjustment costs of R&D investment may work against pronounced ısitivity of R&D spending to transitory shocks in cash flow. Lach and ıankerman (1989) empirically verified the persistency in the R&D data.

Moreover, this effect will actually dampen the long-term response of R&D to cash flow variation. It should however be noted that if a firm management anticipates high fluctuations in its cash flow and unavailability of external finance, then the respective R&D budget may favour projects that have a relatively short duration or are relatively flexible in terms of adjustment opportunities. R&D projects are heterogeneous, and managers may be able to choose short-term R&D projects over ultimately more profitable long-term ones if financing constraints are anticipated. A sequence of short-term projects can be adjusted far more easily than long-term projects, which cannot be accelerated or slowed down without some penalty.

The above theoretical discussions pointed out two things: Firstly, internally generated resources are readily available, more flexible to mange and above all it is less costly. Secondly, external sources of resources for R&D investment are generally unavailable, costly and may also have adverse impact on the long run financial health of the firm.

2.3 EMPIRICAL STUDIES

In the literature empirical studies have followed two sets of approaches. One set employed some specific models to find out the relationship between R&D and cash flow while the other simply regressed a variable measuring internal cash flow (along with a few other variables) on the variable indicating R&D activity. Further some studies have employed a consolidated variable representing internal finance (profits plus depreciation and depletion reserves) while others opted for profits and depreciation and depletion reserves as two separate variables indicating two different sources of internal finance. Most of the empirical studies found a positive association between internal finance (profitability) and subsequent R&D investment. Some studies also reported a weak relationship. Still others did not notice any relationship at all.

For a sample of 67 US manufacturing firms for the four years 1957-60, Mueller (1967) found that profits affected subsequent R&D outlays of firms positively. Grabowski (1968) also observed a positive association between internal sources of funds, measured as the after tax profits plus the depreciation and depletion charges, and subsequent R&D, measured through patent counts. For his study, he employed a sample of 41 large US firms for the period 1959-62. Grabowski and Mueller (1972) investigated the relationship between sources of internal finance and subsequent R&D. They employed a data set covering 66 US firms from seven industries spanning over the period 1959-66, and found positive effect of profits and depreciation reserves on subsequent R&D expenditure.

Branch (1974) also got some support for his hypothesis that profits lead to R&D. His data set covered 111 large US firms over the period 1950-65. Farber (1981) and Lunn (1986) support these findings. While Farber found a positive association between profits and subsequent R&D efforts, Lunn noticed the positive impact of internal cash flow measured as the ratio of the sum of operating income and depreciation to the net sales on product and process patents for the high tech industries. In a recent study, for the period 1983-1987, Himmelberg and Petersen (1994) also found a positive association between internal cash flow and subsequent R&D. However, his study is based on a data set containing 179 small firms of the US. In another study Himmelberg and Petersen (1994) present an investigation of the effect of financing constraints on relatively small U.S. firms in high-technology industries. They show that R&D expenditures are being smoothed according to the permanent component of cash flow. Their argument is that firms face relatively large adjustment costs in their R&D activities and cannot adjust the intensity of these efforts to short-term liquidity shocks. As argued before, these results are subject to the critique that cash flow effects cannot be interpreted unambiguously as indicators of financial constraints.

Hamberg (1966) did not find any consistently significant positive relationship between R&D intensity and variables representing liquidity for any industry. In Pharmaceutical and medicine industry, the coefficient for the

profits was significantly positive while for the depreciation it was significantly negative. His investigation covers a sample of 405 US firms distributed over 17 manufacturing groups for the year 1960. Similarly, for a sample containing 140 large US manufacturing firms for the years 1978-1982, Guerard et al. (1987) did not notice consistency in the positive relationship between profits and subsequent R&D. For instance, the positive impact of profits on subsequent R&D was significant only in one of the years; Depreciation reserve was positively significant in two of the years. Switzer (1984) also found a relatively weak positive relationship between internal finance, defined as the sum of profits before tax and depreciation and depletion allowances for the firm divided by firm sales, and R&D intensity, defined as R&D expenditures to sales ratio. His data set covered a sample of 125 firms belonging to the chemicals, petroleum, electronics and aerospace for the US for the year 1977.

Scherer (1965) did not find prior profitability to affect the inventive output measured as the number of patents issued. Similarly, Hula (1988) and Morbey (1989), and Kumar and Saqib (1996) also did not find any significant positive association between profitability and ensuing R&D intensity. Morbey (1989) did his study for a sample of 800 large US corporations doing R&D over a period of 1976-1985.

In recent past some studies analyzed the relationship between cash flow and R&D investment. Bernstein and Nadiri (1986) have produced evidence that liquidity effects may also be at work in determining R&D activities. Similarly, Hall (1992) finds that the elasticity of R&D with respect to cash flow is positive and significant in a large sample consisting of 1247 publicly traded and R&D-doing manufacturing firms of the U S from 1973 - 1987. She also observed that debt is not favoured as a form of finance for R&D -intensive firms: leverage ratios and R&D investment are strongly negatively correlated across firms. Further Hao and Jaffe (1993) found a positive relationship between internal cash flow and R&D investment. Kathuria and Mueller (1995) also found internal cash flow significant in explaining variations in the R&D investment for most of the years considered for the

analysis. Their data set contained 387 US corporate firms over the years 1972-90. They did cross-section analysis for each of the years considered. They used a model similar to the Q-model for basic specification of the R&D equation.

Some studies found variation in the sensitivity of internal cash flow to R&D for different countries. For instance, Hall et al. (1998) tested the sensitivity of R&D investment to the cash flow for a balanced panel data set consisting of 204 US, 156 French and 221 Japanese R&D doing manufacturing firms for a period of 1978- 1989. The data set included firms in the high technology sectors, viz., pharmaceuticals, electrical machinery, computing equipment, electronics and scientific instruments. She found R&D as highly sensitive to cash flow in the United States than in France and Japan. She attributed these variations in the results to the differences in the corporate governance and financing institutions.

Harhoff (1998) noted the variation in the relationship between cash flow and R&D investment for different size group of firms. His data set contained an unbalanced panel of 236 German manufacturing firms over the period from 1987 to 1994. He found R&D as positively sensitive to the internal cash flow measured as the sum of net income plus the depreciation reserves plus the R&D expenditures. However, this sensitivity was greater for the small firms rather than large firms.

2.4 R&D AND INTERNAL FINANCE: INDIAN FRAMEWORK

It is generally true that higher leverage entails higher shadow price of funds, only a select few mature firms are likely to face a smoothly increasing loan interest rate. In India barring a few largest firms that have maintained a good track record, others have lesser access to the centralized impersonal debt markets. Thus most of the firms obtain bond financing through private placements, usually with non-bank financial institutions (NBFI) or

developmental financial institutions (DFI). The financing from NBFI /or DFI are restrictive (than the open debt market) with respect to the minimum level of the requirement for the working capital, dividend payments, stockholders equity and even capital spending. Moreover, during the periods of tight credit, they are often denied loans in favour of better quality borrowers, who could even obtain funds from the centralized security markets. Similarly, the credit from banks restricts operational flexibility and requires particular level for certain financial ratios. In the competitive market with shortening product cycle a firm cannot wait for the loans to launch its R&D projects. In recent past venture capital funds have emerged as a new source of funding for the risky ventures like R&D. This is true however only for the western countries. In developed countries, venture capital funds are an important source of finance in most of the stages of the innovative efforts (Prakke, 1988). However, in a country like India, venture capital as a source of R&D financing is practically negligible (Mani, 1999). Thus internal sources of finance seem to be crucial for R&D investments for most of the Indian firms. Even for firms that can generate resources from external sources like new equity issues and borrowing, the issues of transaction costs, asymmetric information, financial distress, agency problems, managerial discretion and problems of collateralization favours for internal resources for R&D investment. Thus any positive fluctuation in internal finance is expected to affect the R&D investment of the firms positively.

2.5 OTHER DETERMINANTS OF R&D

In conjunction with the above, technology outsourcing and several other factors also determine the level of in-house R&D investment of a firm. The technology may be outsourced from within the country or from abroad: The main sources of technology from within the economy include other firms (within the industry to which the firm belongs or outside) and public research institutions or laboratories. Technology outsourcing from abroad (imports) takes place mainly through three modes: (a) Disembodied technology imports

through market ('arms-length' purchase of technology against lump sum and royalty payments), (b) Intra-firm transfer of technology through foreign direct investment (FDI), i.e., equity participation and (c) Technology transfer through the imported capital goods (machinery and equipment), where technology is embodied in the capital goods itself. In Indian case technology outsourcing from other firms within the country is very uncommon. Some firms (smaller) do collaborate with public research laboratories for know-how. However, this kind of transaction is rare for the private corporate firms. This is because of the two reasons: Firstly, the technologies developed at the public research laboratories are commercially not very successful. Secondly, corporate firms have preference for the foreign technologies. They see recent policy liberalization in terms of foreign technology collaboration as a good opportunity to acquire technological capability. Moreover, the data is unavailable at the firm level to examine such possibility.

The aforementioned three relevant technology-outsourcing factors, viz, technology import from abroad, capital goods import from abroad and FDI are likely to influence R&D investment of firms differently. Thus the possible impact of these factors should be seen separately. The other important factors influencing R&D investment of firms are firm size, sales growth, capital investment, marketing efforts, export competition and import competition. All these factors including three possible technology outsourcing variables are briefly introduced with their possible relationships with R&D investment as follows:

2.5.1 Technology Imports

There are essentially two views on the relationship between technology imports and in-house R&D investment. First viewpoint argues that the availability of external technology may discourage and hence substitutes for in-house R&D activities of firms. A second, and contrary, view stresses upon the complementarity between in-house R&D activities and external know-how. In-house R&D activities are often indicated as reducing some of the inefficiencies and problems associated with external acquisition of technology.

It is also seen as way whereby externally acquired know-how may be improved and modified to suit the local environment. The adaptive activity provides the firms with an opportunity for technological learning by doing, which in turn, gives it the experience to subsequently develop altogether new in-house technology. Sen and Rubenstein (1989) identified and described the role of in-house R&D in alleviating the problems in various phases of the process of acquiring and implementing external technology. Cohen and Levinthal (1989) argued that firms invest in R&D not only to pursue directly new process and product innovation, but also to develop and maintain their broader capabilities to assimilate and exploit externally available information.

Among the empirical studies some found positive relationship between imported technology and in-house R&D investment [e.g., Desai (1980), Lall (1983) and Katarak (1985, 1990), Siddharthan (1988,1992)]. Some observed negative relationship between them [e.g., Odagiri (1983)]. Insignificant relationship has also been observed in certain studies [e.g., Kumar and Saqib (1996)].

2.5.2 Imported Capital Goods

In general, some technological knowledge is embodied in new capital goods imported from developed countries. For instance, some of the technological knowledge is imported through the purchase of machines, machine parts, or turnkey plants, which later on required only minor modifications to suit the local factor endowments and markets. Sometimes such kinds adaptive research and development on purchased capital goods bring petty patents to the firms. This implies that imported capital goods induce R&D efforts by the firms. Sometimes technology embodied in capital goods supplied by other firms is available at a real price and is a substitute for some types of R&D activity. This view entails that imported capital goods negatively affect the in-house R&D by the firms.

2.5.3 Firm Size

There is a voluminous theoretical as well as empirical literature on the relationship between firm size and R&D investment. There are innovation capability advantages of large firm size stemming from economies of scale in R&D and management, greater capability of risk spreading, appropriability advantages, production and productive capacity, marketing arrangements, finance etc. In particular, large firms tend to have the relative innovative advantage in industries, which are capital-intensive, concentrated, and advertising-intensive and imposing significant entry barriers. However, the beauracratic control structure of large firms may partially or even fully offset these latent advantages. The large firm size is said to stifle creativity and makes firms sluggish in responding to opportunities.

Small firms tend to have the relative innovative advantage in highly innovative industries and in industries, which tend to be composed of a relatively high proportion of large firms. The opportunity for small firm innovation tends to be highest when the industry is in the early stages of the product life cycle. Because in these stages, the product design is subject to rapid change and evolution, a relatively high level of skilled labour is required, while the production process remains fairly labour intensive. Thus the innovative opportunities for the small firms are presumably greatest during the early life cycle stages, and the least in the mature and declining stages, when product innovations play a relatively minor role but capital-intensity becomes a more prominent feature (Acs and Audretsch, 1987). This view suggests that small firms have advantage in product innovation rather than process innovation strategy.

The small firms, particularly in less developed countries, acquire technological capabilities through imitative approach, reverse engineering of foreign products, and recruiting technical personnel from large and multinational firms. Sometimes effectively translation of explicit knowledge of literature and that embodied in equipment into tacit knowledge, spiral and cumulative process of learning and cooperation with government R&D

institutions help them build these capabilities. On the other hand the large firms build technological resources mainly through foreign technology transfers and large-scale in-house R&D activities (Kim Linsu, 1997).

Numerous studies have been conducted at various periods of time to establish the positive relationship between innovative efforts and firm size variable but without any firm conclusion. Some of the studies have supported this hypothesis while others have refuted altogether. Still some others have a different explanation for the said relationship. The dominant and reconciliatory viewpoint is that the level of R&D effort increases with firm size to a certain limit and thereafter it starts declining. Again when firm size becomes very large they renew their efforts for R&D. [For recent surveys, see, Cohen and Levin (1989) and Kumar and Sidharthan (1997)]. In the present context, when sample contains only intermediate to large firms, it means that R&D efforts would be negatively associated with firm size and positively to its quadratic term.

2.5.4Sales Growth

The size of the innovative efforts is also determined by market demand conditions. The growth rate of firm sales may be used as a reflection of market elasticity of demand. Normally, firms allocate funds to innovative efforts as some percentage of their sales. Thus as sales grow, more funds are likely to be invested in the innovative efforts.

2.5.5 Capital Investment

The introduction of new products and strengthening the manufacturing capabilities for the existing products are equally important for the firms. While innovative activities help the former, capital investment is essential for the later. Thus the innovative activities and capital investment may be presumed as the two alternative means to achieve similar goals. Since capital investment competes with expenditure on in-house R&D investment for the same funds, a negative relationship between them may be expected. However, Nelson (1980) argued that the degree of technique codification

might be important in explaining research activity, and links codifiability to the degree of mechanization. This suggests that the capital investment of a firm may complement its R&D effort. The empirical studies have mixed findings. The study of Lunn (1986) found an empirical support for positive relationship between capital investment and R&D efforts. Guerard (1987) also found R&D expenditures to be positively associated with capital investment; however, the relationship was not significant in all of the years (1978-1982). On the contrary, Grabowski and Mueller (1972) and Switzer (1984) did not find any significant association between R&D and investment. Further, Mueller (1967) found an inverse relationship between investment and R&D.

Nelson (1980)' codifiability argument seems to be appropriate for the Indian manufacturing sector where process innovation rather than product developments prevail. Thus we may expect capital investment to be positively associated with R&D investment.

2.5.6 Advertising and Selling Expenses

If the incentives to spend resources on innovative activities (R&D) are higher in markets characterized by imperfect competition[2], then the marketing efforts (advertising) should also have positive effect on innovation. By increasing the demands for new products and raising the size and speed of the anticipated profit payoff of innovative activities, advertising may be able to spur the R&D expenditure upon which innovation depends (Hula, 1988). This effect assumes significance while doing R&D for developing new products for the market launch rather than for researches at basic and applied stages. New product development and introduction is quite expensive and risky. Thus before undertaking it, firms must be convinced beyond a reasonable doubt that the demand for the new product is sufficient to at least recoup their expenses. Marketing effort also becomes essential to disseminate information regarding cost reductions of the existing products achieved through process innovations. Since most of the firm R&D, particularly in Indian case, consists

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[2] Schumpeter (1950) and his followers described at length how monopoly power arising due to the imperfect competition provides an incentive to additional R&D investment. Their views

of new product launches rather than basic and applied researches, the potential effect of advertising on firm R&D is considerable.

The importance of advertising in inducing R&D is well recognized in the past. For instance, Blank (1964) argued that by acquainting the consumer with the values of new products advertising widens the market for these products, pushes forward their acceptance by the consumer, and encourages investment and entrepreneurship necessary for innovation. Mansfield et al. (1977) also emphasised the need to link advertising and R&D decisions. According to them " successful innovation depends in an important way on the R&D being integrated with the marketing. The R&D personnel must be able and willing to respond to the marketing personnel's needs, and marketing personnel should be involved in R&D and project selection" (PP 33).

In their empirical investigation, based on the data from sixteen major firms, they got considerable evidence that the probability of technical completion, commercialization given technical completion, and economic success given commercialization are influenced by how quickly R&D projects are evaluated from the point of view of economic potential.

Advertising can make the demand for a firm's brand more price inelastic and also decrease the cross-price elasticities of demand with respect to rival brands. Since advertising is also done to make the buyer aware of a high quality brand, there is an incentive to invest constantly in innovations; otherwise, advertising expenditure will have a smaller return. Consumers will quickly learn that brand with high advertising budgets do not necessarily provide exceptional qualities. Farber (1981) argued that advertising and R&D are complementary inputs in increasing demand. When product differentiation is feasible, firms use both advertising and research activity as strategic policies.

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are however contrasted by Arrow (1962) others who opined competitive markets more conducive for innovations.

Empirical evidence is mixed. Some studies found R&D intensity to be negatively associated with the advertising intensity (e.g., Connolly and Hirschey, 1984) implying that advertising and R&D expenditure competed for the same sources of funds. On the other hand, (Hula 1988) supported the positive relationship between advertising and R&D intensity. However, Lunn (1986) found the positive association only for new products development in the consumer goods industries. In a recent study Schulenberg and Wagner (1997) found negative association for German data while positive relationship for the US data.

Despite conflicting evidences we expect Indian firms to invest a priori in marketing activities to boost the prospects of their ensuing R&D investment. Given the uncertainty in the Indian market firms cannot be expected to take the market risk for their costly R&D investments. They must get ensured through their marketing activities to cover at least the cost of their R&D investments before moving for actual ventures. Thus a positive relationship between marketing efforts and in-house R&D investment may be expected.

2.5.7 Import Competition

The recent changes (since 1991 and thereafter) in the import policies such as abolition of quota system and downward rationalization of the tariff structures, have led to increased imports in the high-tech manufacturing products. Increasing imports, in turn, are likely to affect domestic[3] firms' market shares and profitability adversely[4]. Increasing R&D efforts may be one of the several ways for the domestic firms to improve their market share and repel the threat from import competition.

Among the earlier studies, Scherer and Huh (1992) and Zimmermann (1987) explored the effects of imports on innovative activities of the US and German firms, respectively. Bertschek (1977) investigated the effects of

[3] The domestic firms comprise of both indigenous enterprises and the subsidiaries of the multinational enterprises.

import share on the process and product innovations for the German manufacturing firms.

Scherer and Huh found a more or less negative effect of high technology commodity imports on R&D expenditure of the 308 U.S corporate firms over the period 1971-87. However, the results may not be called robust, as the estimated coefficients of the import competition variable in most of the specifications are insignificant. In a study considering two sub-samples (1041 non-exporting and 2878 exporting), Zimmermann found a positive and significant effect of imports only on product (not on process) innovation and only for the exporting firms.

2.5.8 Export Pressure

In Indian manufacturing sector a dual quality control system is in operation. Due to the higher standards and strict quality enforcement in developed countries, producers are required to maintain higher quality standards for exported items, which in turn, forces Indian firms to do some in-house R&D. Thus a positive relationship may be expected between the export and subsequent R&D efforts.

2.5.9 Foreign Direct Investment

There are at least two reasons in favor of a positive association between foreign direct investment (FDI) and R&D efforts by domestic firms. Firstly, FDI, which mainly comes through the subsidiaries of the multinational enterprises (MNEs), allows for the transfer of production technology and for producing and selling of commodities in the host countries' markets which, in turn forces the domestic firms to improve efficiency of production (Bertschek, 1995). Secondly, FDI may cause some knowledge spillovers, thereby lowering the cost of domestic R&D and making the R&D efforts by domestic firms profitable (Walz, 1997).

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[4] The pragmatic view of competitive gains from trade may be seen in the surveys on the literature by Jacquemin (1982) and Hay and Morris (1995). For recent studies, see Kaluwa and Reid (1991), Weiss (1992), Katics and Peterson (1994), among others.

The empirical studies however have mixed findings. In a study conducted on a sample of 47 Belgian domestic firms over the period 1980-83, Veugelers and Houte (1990) observed the presence of MNEs to have a negative impact on the domestic firms' R&D efforts. They interpreted this negative result as a reflection of the relatively low price-cost margin of the local firms compared to that of MNEs or a low substitutability between the products offered by these two groups. In another study, Bertschek (1995) investigated the effects of FDI share on the process and product innovations for 1270 German manufacturing firms for the years 1984-88. His results suggest significantly positive effects of FDI share on process and product innovations.

2.6 OWNERSHIP STRUCTURE

The conduct and performance of multinational enterprise (MNE) affiliates[5] operating in less developed countries (LDCs) are typically viewed as intrinsically different from local firms. They are supposedly more powerful and dominant within the manufacturing community with more advanced and latest technology, most efficient techniques of management, financing, marketing, production and quality control [Lall (1978), Mendez (1983), Fairchild and Sosin (1985), among the others]. In order to maximize the possessed intangible resources such as internationally recognized brand names, captive access to technology and reservoirs of technical, managerial and organizational skills, MNE affiliates generally pursue the non-price mode of rivalry – such as R&D and advertising - than their local counterparts (Caves, 1982). In addition to development of new products and processes, R&D activity by the MNE affiliates are also undertaken to improve and differentiate the design and quality of the existing products from competing brands. Further extensive advertising and marketing campaigns are accompanied to disseminate the differentiating features of their products among the potential

[5] A firm is referred to as an MNE affiliate in which at least 25% foreign equity ownership is held by an Indian affiliate of foreign-based Multinational Corporation (in tune with the Reserve Bank of India's definition of a foreign controlled rupee company).

customers. Moreover MNE affiliates also enjoy the goodwill and reputation about their products created by global advertisement campaigns launched by their parent companies. Traditionally it was argued that subsidiaries of multinational corporations source their technology mainly from their parent organization. However various studies point out the decentralizing tendency of R&D units among multinational firms towards their affiliates across the world including less developed economies[6]. Except original technology, which is inherited from the parent firm, all other technological developments such as local market and resource adaptive research are generally taken place in the multinational subsidiary firms. Easy access to financial resources and large firm size of MNE affiliates give them an added advantage in realizing economies of scale out of R&D projects and advertising and marketing expenditures[7]. All these aspects point out that the R&D behaviour of the multinational affiliated firms are likely to be different than their local counterparts. Thus the present study will investigate the determinants of R&D for MNEs and LCEs separately to assess the possible differences between them. The other issues of differences between MNE affiliates and their local counterparts such as organizational, financial, management etc. will be left aside to keep analysis focussed on the technological issues only.

[6] The factors affecting the decentralization of R&D units by multinational corporations can broadly be segmented into two categories: demand and supply side factors. The important among the demand side factors include the incentive to access foreign markets, to improve firm's capability to respond to specific requirements of local markets and to increase proximity of product development activities to key customers. Supply side factors include the need to tap into foreign scientific infrastructures, especially abundantly and cheaply available qualified scientific and technical personnel. Sometimes political and image factors also influence the decentralization of R&D units by multinational enterprises [for details see, for instance, Hirschey and Caves (1981), Kumar (1996), and Chiesa (1998)].

[7] MNE affiliates are on an average larger than their local counterparts (Lall and Streeten, 1977).

CHAPTER 3

R&D AND PROFITABILITY

3.1 INTRODUCTION

The research and development (R&D) of a firm is posited as an aspect of conduct or non-price rivalry, which a firm employs to gain edge over its rivals. Schumpeter (1950) maintained that monopoly power provides with the profits and security to take risks involved in uncertain R&D investments. The successful innovations generate excess profits and may also create barriers to entry to protect these profits from potential entrants[1]. Incumbent firms enjoy a cost advantage over potential entrants as a consequence of superior technology. The excess profits and barriers to entry however get eroded in the face of diffusion of technology to potential entrants. But the technology diffusion takes place with some lag. In the process, existing firms generate further technological innovations, which continuously recreates their cost advantage over potential entrants (Levin 1978).

The rest of the chapter proceeds as follows. Section 2 outlines a theoretical framework linking R&D and profitability. Section 3 surveys the concerned empirical literature. Section 4 briefly summarizes other factors affecting the profitability of firms. Section 5 summarizes the main hypothesis.

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[1] The other sources of entry barriers are – economies of scale in production, absolute cost advantage of incumbent firms, product differentiation, absolute capital requirements (Bain, 1956) and advertising intensity.

3.2 THEORY

A number of papers modeled the effects of R&D on cost reductions for the oligopolistic industries. [e.g., Dasgupta and Stiglitz (1980), Flaherty (1980), Spence (1984), Tandon (1984), Dixit (1988), Quirmbach (1993) Leahy and Neary (1997), among others]. A handful of works also considered creation of new products [e.g., Levin and Reiss (1988), Jovanovic and MacDonald (1994), among others][2]. The essence of all these theoretical works is that successful innovative activities may enhance the profits in at least two ways. Firstly, cost-reducing process innovation widens the profit margin earned on a rupee of sales. In a competitive market where price of a product is given, if a firm develops a process innovation which lowers its average cost, the firm will increase its profits by the decrease in average costs times its ex ante level of output. Scherer (1984) however noted that a profit-maximizing firm, facing a downward sloping demand schedule, prices in the elastic portion of the demand schedule with constant or rising marginal cost. A reduction in marginal costs reduces its profit-maximizing price and increases its sales revenue. This observation implies that the growth of sales at more or less constant profit margins, rather than the expansion of profit margins is the main reason for the growth of profits associated with cost reducing innovative activities. Secondly, product R&D create new or improved products, which shifts the demand schedule of the firm rightwards. Product innovation may increase the firm's price-cost margin through the introduction of new product features that increase the price buyers are willing to pay for the firm's product. In contrast, however, to process innovation, which reduces costs on existing output, the product innovation allows the firm to reach new buyers as well as to raise price given some degree of transient monopoly power. Accordingly, a firm's product R&D can be viewed as creating a variant of its product that embodies new or improved features that yield monopoly rents until they are imitated. Due to differences in buyer's preferences over product features, some of the firm's current buyers will buy the new variant at higher price. Thus the firm will extract monopoly rents from only a fraction of its ex ante

[2] Reingnum (1989) presents a nice survey of R&D competition models, especially "auction", "stochastic racing" and "contest" models.

output. The new product variant will also appeal to new buyers, offering opportunities for output expansion or licensing to competitors. Sometimes R&D also helps in product differentiation and product diversification. Moreover, R&D is an effective tool for information creation and dissemination process (Megna and Mueller, 1991).

The R&D expenditures also provide entry barriers to new entrants and thus expected to lead to above average returns [See for instance, Phillips (1966), Mueller and Tilton (1969), Stonebraker (1976), among others]. Barriers to entry permit higher profits, and a given increase in profit rates attracts fewer entrants in a high barrier than a low barrier industry. The entry barrier effects of R&D may be because of at least two reasons. Firstly, the extent of economies of scale involved in R&D processes itself. Economies to scale barriers have been postulated to arise from R&D because investment in it is costly, risky, and subject to economies of specialization in personnel and equipment. This means that a critical or threshold level of investment may be necessary to do R&D efficiently. Further the pursuit of several R&D projects simultaneously allows firms to diversify much of the risk associated with the undertaking of only a few projects. These factors may serve to deter entry at small scales of operation in industries where R&D expenditures and product quality changes are important to establishing and maintaining market shares. The need to undertake large-scale R&D investments can also be a source of absolute cost barriers. Moreover, these may be because of the intangible nature of the capital stocks arising from the R&D. In contrast with the investment in the plant and machinery, investment in R&D often provide little collateral against the contingency of failure. Hence, existing firms (with established records of performance) may receive investment financing on favorable terms than the new entrants, even where the objective risks of failures are similar. Secondly, the accumulation of patents and know-how on the part of incumbent firms strengthens a firm's competitive position vis-à-vis its rivals. The process of innovation fundamentally transforms a firm, building up its core competencies in a variety of ways that make it quicker, more flexible, and more adaptable in dealing with market pressures than non-innovating firms. Even if rivals successfully imitate and begin to eat into the

innovator's high profits arising out of existing operations, incumbents experiences of past innovations often gives birth to newer innovations and paves the ways for continual rise in sales revenue and profits.

In addition, if R&D projects have above-average risks and the opportunities to pool these risks are limited, R&D investments may entail the bearing of above-average risks even on the part of large established firms. If this were so, one would expect firms investing heavily in R&D to earn risk premiums and exhibit above-average returns on total capital. However, in contrast to the entry barrier view, a significant part of the returns will be competed away by vigorous intra-industry rivalry in R&D activity[3]. It should be noted that it is very difficult to coordinate outlays for innovative activities at joint profit maximizing levels even within highly concentrated industries (Grabowski and Baxter, 1973). The R&D rivalry hypothesis is supported by the findings of Grabowski and Mueller (1978) and of Connolly and Hirschey (1984). Grabowski and Mueller (1978) noticed strong negative R&D-market concentration interaction effect for the research-intensive industries. And with the inclusion of this variable, concentration ratio became insignificant though positive. On the other hand, Orr (1974) found technology intensity to be an important and statistically significant barrier to entry, along with other standard sources of entry barrier. Moreover, he observed technology activities, especially, product innovations and adaptations as important sources of product differentiation. Kumar (1990a)'s findings for Indian manufacturing sector also support that technology intensity is an important entry barrier in technology intensive industries.

3.3 EMPIRICAL STUDIES

Scherer (1965a), Branch (1974) and Grabowski and Mueller (1978) found an early support for the positive effect of R&D on profits. Scherer

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[3] R&D intensities increase with concentration over much of the oligopolistic range (Scherer, 1967). However, increased concentration in research intensive industries leads to increased rivalry in R&D and pushing firms into diminishing marginal returns on R&D, and hence lower the profit rates.

(1965a) did an inter-industry study to examine the relationship between inventive efforts, profitability and sales growth for a sample of 448 large US firms over the period 1955-1959. He used the number of patented inventions and profits-after tax to measure the R&D efforts and corporate performance respectively. His regression estimates indicate that corporate profits were positively related in normal times to inventive output. Further, his decomposed analysis show that the bulk of corporate inventive activity worked its favorable effect on profits by facilitating the growth of sales at constant profit margins rather than by widening profit margins. It is also appeared from his analysis that business recessions affected sales and profits of highly inventive corporations unfavorably.

Branch (1974) tested the hypothesis that R&D may stimulate subsequent profits. He employed the distributed-lag techniques with pooled time series and cross section data to discriminate between over time and across firms' relations. His sample for the study consisted of seven industries – chemical, electrical equipment, paper, mechanical equipment, non-ferrous metal, petroleum and drugs - containing 111 large US firms covering the 1950-65 period. He used patents as a proxy for R&D efforts and profit after taxes plus interest as an index of firm's return on its resources. R&D activity and profits plus interest were deflated by assets. His results strongly support the hypothesis that R&D activity increased both profits and sales growth in all industries except drugs, where sales increased but profits declined.

For a sample of 150 US firms belonging to the research-intensive industries for the period 1959-66, Grabowski and Mueller (1978) investigated the relationship between R&D capital and profitability. They found that after tax- profit (adjusted for R&D capital) was significantly and positively related to the R&D intensity measured as the R&D capital divided by the total capital assets including R&D capital.

For a sample covering 310 US firms across 24 industries over the period 1974-80, Parsuraman and Zerene (1983) found that R&D expenditures had fairly strong associations with subsequent profits and sales though their

results differed for different industries. Further, the time-lagged impact of R&D expenditures indicated a stronger effect on sales than on profits.

Griliches (1981) estimated the relationship between R&D and patents and market value of the firm for the 157 US firms over the period 1968-74. His estimation shows that it is not the past R&D but the unanticipated R&D expenditures and patents that have the positive effect on the market value of the firm.

Connolly and Hirschey (1984) examined the relationship between R&D to sales and excess market value to sales for a sample of 390 fortune 500 firms for the year 1977. They found that R&D intensity stimulated excess value intensity positively.

Pakes (1985) investigated the relationship between successful patent applications, a measure of inventive efforts, and the movements in the stock market value of the firm's equity, a measure of R&D performance for the 120 firms of US manufacturing sector covering the period 1968-75. The events that lead the market to re-evaluate the firms are indeed significantly correlated with unpredictable changes in both the R&D and the patents of the firm. Moreover, the estimates, on the average, imply that unexpected change in patents and in R&D are associated with quite large changes in the market value of the firm. Nevertheless, there is a large variance to the increases in the value of the firm that is associated with a given increase in its patents. Movements in the stock market rate of return do seem to be a result of unpredictable events, and stock market evaluations should not depend on the long and erratic structure between invention and the current benefits derived from it.

Jaffe (1986) examined the relationships between R&D capital and gross operating profits and that between R&D capital /total capital and market value, defined as Tobin's q, for the two cross sections centered on 1973 and 1979 covering the periods 1965-72 and 1973-79 respectively for the 432 US

firms. The results supported the hypothesis that R&D affected profits and market value of the firm positively.

Morbey (1989) studied the relationship between R&D intensity measured as R&D expenditures to sales, and profitability measured as the net income before extraordinary items to sale, and rate of profit growth measured as a percentage annual average change in net income. He did several kinds of analyses to investigate the relationships between R&D intensity and subsequent profitability and also to examine the relationship between profitability and ensuing R&D intensity for a sample of 800 large US corporations doing R&D over the period 1976-1985. In his cross-section of industry composite analysis he found that R&D intensity was strongly negatively correlated with the all-industry composite profitability. His across industry analysis did not show any significant relationship between R&D intensity and growth in profits. In addition, profit growth was not correlated with the ensuing R&D intensity. However some significant correlation was observed between R&D intensity and subsequent profit growth and weak association between profits and ensuing R&D intensity for high-research intensive industries. Further, in his across firm within the industries he noticed some significant relationship between R&D intensity and subsequent profit growth only for computer, chemical, paper and machinery industries. For all other industries this relationship was either weak or negligible. The relationship between profit growth and ensuing R&D funding levels was non-existent in all industries except machinery industry.

Kim and Lyn (1990) found the link between R&D intensity, measured as the R&D expenditures to net sales ratio, and excess market value, as measured by Tobin's q. His data set included a sample of 54 foreign owned US firms distributed among thirty-five 4-digit SIC industries.

Geroski et al (1993) investigated the effects of innovations, measured as number of major innovations on corporate profits (profit before tax) for a sample of 721 large, quoted UK manufacturing firms containing 117 innovating and 504 non-innovating firms observed over the period 1972-1983.

His results showed that the number of innovations produced by a firm has a positive but, on an average, modest effect on its profitability. Moreover, innovation caused some generic differences in competitive ability between innovating and non-innovating firms. Further, innovating firms enjoy higher margins because of their higher market shares than non-innovators, and because the margins associated with possessing a market share of a given size are higher for innovating firms. Finally, the profit margins of innovating firms are somewhat less sensitive to cyclical downturns than those of non-innovators.

Hall (1993) found that stock market value and the gross rate of return to R&D investment (old as well as new) fell in comparison to investment in physical capital during the 1980s, for a sample of more than 3000 US manufacturing firms covering a wide number industries. However, this fall was rather modest in pharmaceutical industry.

In a cross-section of 30 industries covering only medium to large corporate firms for the years 1975-1978, Siddharthan and Dasgupta (1983) found the impact of R&D intensity, measured as R&D to sales, on profits, measured as profit after tax to net worth, negligible.

Kumar (1994) also examined the relationship between R&D and profitability. The data set contained 43 Indian manufacturing industries for the years 1979-81. His results show that the technology variable, measured as the ratio of R&D expenditure plus royalty and technical fees to net sales, positively influenced profits of MNE subsidiaries only.

The preceding empirical studies largely show a positive impact of R&D on profits. Few of them also noticed weak relationship. The Studies for Indian manufacturing sector did not observe any connection between R&D and profitability, especially for local enterprises. The reason for the variation in the results for the studies conducted for developed economies and India seems to be the differences in the policy environment. The Indian studies are based on the data set pertaining to the pre-liberalization era where technological factors

were not considered important for competition among the Indian manufacturing firms. As mentioned in the introductory chapter, the Indian policy regime after liberalization (since 1991) has become market driven. And technology is likely to play an important role in shaping the competitive environment in Indian manufacturing sector. Thus we can expect a positive relationship between R&D efforts of firms and their profitability.

3.4 OTHER DETERMINANTS OF PROFITABILITY

Apart from the R&D investment, the profitability of firms also depends upon the possession of complementary assets such as, marketing channels, manufacturing capability, brand image, market power, etc. [Teece (1986)]. In general, the other factors affecting inter-firm differences in profits include technology imports, firm size, market demand conditions, capital investment, capital goods import, advertising and selling activities, import competition, export competition and the ownership structure. Some of them are also common to the determinants of the R&D and exporting. All of these factors are listed with their expected relations with profitability of the firms.

3.4.1 Technology Imports

As outlined in the introductory chapter, the recent changes in the industrial and technological policies have put up pressures on the Indian manufacturers to invest in R&D. But at the same time it has offered excellent opportunities to import technologies from abroad. For the Indian manufacturers the effect of imported technologies on their profitability is likely to be similar to the creation of any new product. Given the imperfect technology markets, the technology import intensity has high potency of entry barriers. Thus a positive relationship may be expected between technology imports and ensuing profits.

3.4.2 Firm Size

Firms with a large market size may be more efficient because of the scale economies or greater market power (or higher quality of products) to charge higher prices than their smaller rivals. However, beyond a certain level the diseconomies of scale may also be operative[4]. Hence, a quadratic relationship may be expected between firm size and profitability.

3.4.3 Market Demand

Other things being equal, the sales growth of the firm would influence its profits positively. This is because of the fact that any increase in the market demand of firm's products may increase market prices and/or reduces unit cost due to greater capacity utilization. In either case, it will directly result in increased profits.

3.4.4 Advertising and Marketing Efforts

Advertising and other selling activities aim at shifting the demand schedule for the product of the firm and making it less elastic, allowing it to raise its price or sales or both and increase its profits. In the modern oligopolistic market advertising is a major tool of product differentiation and competition. It helps the introduction of new products and /or sustaining the sale of existing products. Since all of the firms in oligopolistic markets have the same incentives for advertising, a substantial part of it becomes self-canceling. Advertising has become essential to defend and maintain one's market share. The advertising largely cancels itself out mutually among the firms, while market shares remain virtually constant in the long run. The literature on the relationship between advertising and profits consistently shows a positive relationship between them. Schemalense (1989) have nicely presented a recent survey of literature. In our study we also expect a positive relationship between advertising and subsequent profits.

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[4] Larger firms may have to pay higher wages compared to smaller firms. Increasing firm size may also be a sign of a higher degree of X- inefficiency, which in turn reduces profits.

3.4.5 Capital Investment

Higher the level of capital investment indicates either higher the level of automation in the production system or creation of additional manufacturing capabilities. In either case it is expected to affect the subsequent profitability positively.

3.4.6 Capital Goods Imports

Like capital investment, imported capital goods are likely to have positive effect on the subsequent profits of the firms. Even if imported capital goods are seen as a form of imported embodied technology, it will have the similar impact on the profitability.

3.4.7 Import Competition

The import competition may reduce the market power of the dominant firms in a given industry. In effect, it represents dilution of domestic seller concentration due to the entry by foreign competitors. With substantial imports or the threat thereof, domestic firms would be more likely to set import-entry-forestalling prices approaching competitive prices. The expected impact of imports on price cost-margins or profit rates of import-competing industries would thus be negative. The empirical studies have consistently observed a negative impact of imports on the profits. Some recent studies investigating such relationships include Neumann et al (1985), Ghellinck et al (1988), Kaluwa and Reid (1991), Weiss (1992), and Katics and Peterson (1994).

3.4.8 Exports

In contrast to imports, the effect of exports may seem to be ambiguous. If domestic markets are relatively protected, sales to foreign markets are exposed to more competition and hence price-cost-margins (PCM) in foreign markets are less than the PCM in domestic markets. This suggests a negative relationship between increased export ratio and domestic firm's PCM. On the

other hand, if domestic markets are relatively open and a firm is exposed to substantial competition at home and is selling to competitive foreign markets, the difference between PCMs at domestic and foreign markets may be negative or positive depending on the cost of production. Given the lower cost of production, especially for the generic products, and various incentives enjoyed by the exporters of Indian manufacturing sector, any expansion in the exports by a firm may be expected to affect its PCM positively.

It should be noted that exporting is a risky undertaking, which involves increased uncertainties associated with operating in foreign markets (Khalilzadeh-Shirazi, 1974). Thus, until and unless a firm finds itself being rewarded by a risk premium it can not be expected to engage in exporting. Further, even in the extreme case when domestic and international prices are equal, a firm may gain if it is able to produce the product at relatively low costs and vice versa. Furthermore, even in case of a domestic monopolist confronted with increasing returns, firms may be interested in exporting when it helps them to achieve economies of scale (Jacquemin 1982). In the context of Indian manufacturing sector, at least four arguments can be given for a positive relationship between exports and profitability. Firstly, due to the abundant supply of skilled manpower and scientific personnel, the cost of production (mainly of generic products) is relatively lower than abroad. Secondly, preferential treatment provided to the exporters in respect of imported intermediate items and taxes may also lower their cost of production. Thirdly, because of the higher standards and strict quality are enforced in developed countries, exported items from Indian producers may be of better quality, which in turn, may be reflected in higher prices for exported items. Fourthly, recent changes in the foreign sector policies, such as devaluation of the domestic currency vis-à-vis hard currencies, full convertibility of the rupee on trade account and relaxation in the exchange control regime, helped bridging the gap between nominal and real exchange rates, which in turn, made Indian exports attractive.

The empirical studies showing the impact of exports on profits are mixed. Some studies found a negative relationship [See for instance, Caves

et. al. (1980), Siddharthan and Dasgupta (1983), Neumann et al. (1985), Chou (1986) and Kaluwa and Reid (1991), among others]. Some others observed a positive relationship [e. g., Pugel (1980) and Katrak (1980)] and still others [e. g., Jacquemin et al (1980) and Ravenscraft (1983), Hughes and Oughton (1993)] did not notice any relationship between exports and profits.

3.4.9 Foreign Direct Investment (FDI)

There are two equally stronger viewpoints in the diametrically opposite directions for FDI. The first viewpoint treats FDI, which mainly comes through MNEs, as a potential competitor for the domestic producers and hence a negative association between FDI and PCM is expected (Pugel, 1980). The other viewpoint treats MNEs as different "strategic group" within the industry [See, e.g., Caves and Porter (1977) and Kumar (1990)]. This implies that MNEs and LCEs follow altogether different strategic policies. For instance, MNEs may not compete with LCEs but pursue the discriminatory pricing policy and target themselves mainly to the price insensitive upper segment of the market. As a consequence, the average price of the products in the industry may be pushed upwards. Therefore, the possibility of a positive relationship between FDI and PCM may not be ruled out.

Since the FDI, which comes through MNEs, is a close alternative to exports for internationally operating companies (i.e., imports of host countries), the same arguments might hold for FDI. Sometimes FDI and exports by the international players may be complementary instruments [e.g., Veugelers (1991), Yamawaki (1991)]. While imports only allow for the transfer of products, FDI also allows for the transfer of production technology and investment in the sunk costs (e. g, plants and distribution channels). The later shows more commitment and determination on the part of the international operators to operate in the host economy. Further, MNEs may also have the access to locally available cheap trained work force and scientific manpower. Thus domestic firms might see their market position more endangered in the

presence of MNEs than in the case of imports. This argument implies that FDI may affect profitability of the firms negatively.

Caves (1980) however shows that the relationship between FDI and profits may also be positive. If MNEs, which generally have efficiency advantages over local enterprises, adopt higher levels of product differentiation and charge higher prices than their local counterparts. Moreover, MNEs may not compete with LCEs but follow altogether different strategies.

Empirical studies investigating the relationship between FDI and profits have mixed findings. While, Hughes and Oughton (1993) and Ghellinck et al. (1988), among the others, observed a positive association, Chou (1986) and some others noticed a negative association between these two variables.

3.5 OWNERSHIP STRUCTURE

As elaborated in the chapter 2, the MNE subsidiaries (MNEs) and local enterprises (LCEs) clearly stand out to be two different groups within an industry. Being part of global enterprises, MNEs enjoy persistent advantages over their local counterparts in respect of technological strength and learning, reputation, width of product range, and associated services. Because of these inherent differences, there is a general belief that MNEs make more profits than their local counterparts. This anticipation is partly because of the fact that for firms to venture into other countries the returns on their investments in the host countries must compensate for the additional costs to be incurred in learning to deal with their new environment. Moreover, MNEs serve quality conscious and price inelastic upper market segment while their local counterparts concentrate on price competitive lower end. Empirical results however are mixed. For instance, Ahiakpor (1986) examined the hypothesis that MNEs earn excess profits than their local counterparts. His data set contained 297 manufacturing firms (including 119 MNEs) employing 30 or more workers for the Ghana for the year 1970. His results show that the profitability of MNEs is not significantly different from their local counterparts.

Kumar (1990), on the other hand, observed significant differences in the profit margins of MNEs and LCEs. This difference persists even when other variables distinguishing MNEs from the LCEs, such as firm size, growth, R&D intensity, degree of vertical integration, and financial characteristics, were controlled for in a multivariate context. Thus the underlying study would investigate the determinants of profits for MNEs and LCEs separately to estimate possible differences between them.

CHAPTER 4

R&D AND EXPORTING

4.1 INTRODUCTION

A growing body of theoretical and empirical literature analyzed the relationship between technological developments and international trade at macroeconomic level. Some studies also extended the relationship between innovations and exporting at the firm level[1]. The essence of the logic is that innovative activities really take place at the firm level. It is at the firm level where decisions are taken regarding commitment of resources to innovative activities and the benefits of innovations are enjoyed, either in terms of cost reductions or creation of new products or improvement of some feature of existing products. The aggregated benefits and competitiveness of firms are translated into the competitiveness of a country. The rest of the chapter is organized as follows: Section I briefly presents the theoretical and related representative empirical literature linking technology to international trade at macro level. The next section reviews the studies of technology and export at the firm level. The subsequent section discusses how innovations are important for exporting for firms in context of a developing country like India. The last section raises the possibility of other factors influencing the exporting at the firm level.

[1] For recent surveys of literature see, Wakelin (1997) and Kumar and Siddharthan (1997).

4.2 THEORY

In the Heckser - Ohlin - Samuelson (neoclassical) framework technology was assumed to be given for any industry and accessible to all countries. The international trade was determined by the factor endowments: labor abundant countries specialize in production and export of labor intensive commodities while capital abundant countries specialize in production and export of capital intensive commodities, and vice versa. The later extensions of neo-classical theory (also called neo-endowment theory) included knowledge as another factors of production and postulated that the countries possessing knowledge have relative competitiveness in knowledge intensive goods. However, this theory did not recognize the causes of technological advancement and diffusion. Some of the noted empirical studies related to neo-endowment theory are by Gruber et al (1967), Sveikaukus (1983) and Hughes (1986). Gruer et al (1967) showed the role of R&D expenditure and scientists-engineers in the comparative advantage of the US exports. Sveikaukus (1983) found technology factors - measured by R&D expenditures, innovation counts and radical innovations - to be more important factors in explaining US competitiveness than skill and capital intensity. In a study for the UK for the period 1972-78, Hughes (1986) found evidence for the positive role of R&D expenditure on UK export performance.

The technology gap theory of Posner (1961) and subsequent developments explicitly recognized the role played by technology in shaping a country's relative competitiveness in international trade. These theories consider differences in technology as the main determinant of trade. In technology gap theory model of Posner (1961), a country gains a temporary advantage over its trading partners through the discovery of new products and process. For a period of time these innovations remain unique to the innovating country until they are imitated by competitors, and the innovating country loses the advantage. However, the innovating country may continue to innovate, due to its superior technology development capability, and maintain advantage in a stream of new products, losing the advantage in each

product and replacing it with a new innovation. Though technological gap theory recognized the link between technology and trade, but it ignored the possibility of the innovator firms producing in countries with a cost advantage. In his empirical study test the technology gap theory, Soete (1981) considered trade flows across OECD countries within 40 industries and employed patents as the proxy for technology. His results show the importance of technological differences between OECD countries in explaining trade patterns for the selected industries. However, there is a great deal of heterogeneity between the different industries implying that the technological factors are of varying importance depending on the individual industry characteristics.

A parallel to the technology gap theory, Vernon (1966) developed a product lifecycle theory of trade. Like technology gap model, this theory postulates a country with an advantage in producing innovations. At the early stages of production of a good, production remains in the innovating country and the price of good is high and output low. However, as product achieves maturity and becomes more standardized, the price falls, production runs become longer and the production of the good can pass to other countries which have cost advantages in production. The innovating country then produces another new product that remains in the innovating country during the early stages of development.

Krugman (1979) refined the technology gap model to explain the inter-industry trade and technology gap between developed and developing economies. In this model innovative North produces new products and non-innovative South produces the products with time lag but at lower costs. New industries must constantly emerge in the North as the older industries shifted to the South. The higher wages reflect the North's monopoly rent on the new technology. Krugman argues that this monopoly is continually eroded by technological borrowing and must be maintained by constant innovation of new products. This would lead developed nations in the same place. Audretsch (1987) empirically tested and found some support for the life cycle theory. Although the technology gap and product cycle models provided important explanations for the linkages between technology and international

trade. They lack dynamic implications of different levels of tec
countries. This gap has been attempted to fill by neo-shumpeteria

The neo-Shumpeterian approach (Dosi et al 1990) stre
micro-economic features of the technological developments. Accc
approach technology is firm specific, cumulative and based on tl
skills and learning. Essentially it is local and often tacit (non-coc
partly appropriable knowledge. Most of the innovations are
improvements on the existing innovations based on the past exp
the macro level these firm-specific advantages translate into a
advantage for the country. Each country has a particular ex
innovation, which is the aggregation of the innovation experience
as well as through complementarities between different innovatio
industry relationships based on the use and production of innovati

At the international level, Dosi et al. (1990) highlights the gr
of specialization patterns, and dynamic implications they may I
economy. Dosi et al. (1990) argued that the international differer
of innovation are important determinants of both the patterns of t
evolution over time. Further they said that the general
readjustment predicted by the neo-classical models of trade doe
and as a result trade can have an impact on domestic econc
Furthermore, they argued that technology is not a free good,
available internationally through a simple process of diffusion anc
transfer, but rather can be partly appropriated, and is accumulate
and country level. Given the existence of dynamic economies of
production of knowledge, a country can build up a dynamic
advantage in the production of new products. In addition, they p
these advantages can persist over time, causing 'virtuous' and 'vi
of development. Countries can become 'locked in' to particular in
specialization patterns via their own history and experience and t
their institutions, thus providing a microeconomic rationale for the
of technological differences between countries, and the dynamic
of specialization patterns.

Along with developments in the neo-technology theories, the increasing volume of intra-industry trade between developed countries sought an explanation by incorporating some of the features of imperfect competition (such as economies of scale, monopolistic power and product differentiation) from industrial economics to the international trade theory. This literature explains the role of technology in two ways. The first is as a factor adding to product differentiation and thus the technology intensity of products can be used as a proxy for their heterogeneity. Second, the strategic nature of technology confers a strategic advantage to a country by capturing the monopoly rents from innovation [Brander and Spencer (1983)].

Grossman and Helpman (1990) and Krugman (1987) refined the strategic tool view of the technology by treating it as endogenous (Dynamic comparative advantage theory). This theory postulates that comparative advantage can be acquired through experience in research (learning) that raises the relative productivity at R&D, and increases the growth rate of the country through increasing returns to scale. In other words, learning, and cumulative and endogenous nature of the technology leads to endogenous comparative advantage based on the differences in the technology.

In recent past a large body empirical studies, which are not clearly linked to any specific theory of trade, have been conducted at macro-economic level to analyze the relationship between technological change and international trade. These studies stress that innovation provides countries and sectors with comparative advantages stronger and more durable than those based on unit labour costs [See, among many others, Fagerberg (1988), Dosi et al. (1990), Greenhalg (1990), Greenhalg et al. (1994) and Amable and Verspagan (1995)].

4.3 EMPIRICAL STUDIES

The preceding section provides theoretical and empirical justification for the relationship between technology and exporting at the macro level. A similar conclusion should also emerge from micro-economic studies, simply because technological knowledge is embodied in firms, and it is at firm level that the decision to perform innovative activities is taken and the gains from innovation are enjoyed, in terms of cost reductions in the case of process innovations, and new markets and potential monopoly rents in the case of product innovations (Wakelin, 1997). In fact, the few studies carried out at firm level have generally found a positive and significant relationship between innovations and export performance.

The majority of firm level studies on innovation and export performance have employed the intensity of R&D as a measure of innovation. Some of them have also employed other proxies for technological innovations. Hirch and Bijaoui (1985) used the share of R&D employees to explain the rate of change of exports in a cross-section of 111 R&D performing Israeli firms. On controlling for firm size, they found a positive and significant relationship between innovations and exporting of the firms. Similarly, for a sample of 266 Japanese manufacturing firms, Ito and Pucik (1993) observed that R&D intensity (the ratio of R&D expenditures to sales) was a significant determinant of their export performance (the share of export on sales) only when the size variable (total assets) was dropped from the regression.

Lefebvre et al. (1998) did a study for a sample of 101 Canadian firms that performed R&D, had fewer than 200 employees and belonged to the category of 'specialized suppliers'[2]. The results of their Tobit regression show that a firm's R&D intensity does not affect its export performance, but the impact of other technology variables (such as the percentage of employees

[2] Specialized supplier industries - Machine tools, Industrial machinery, Instruments.

with technical and scientific backgrounds and the presence of R&D collaborations with external partners) is positive and significant. For a very large sample of Italian manufacturing firms containing more than 3600 observations Becchetti and Rossi (1998) reported similar results. Although their principal aim was to identify the effect of industrial districts on the export behavior of Italian firms, they found that R&D intensity increases neither the probability of being an exporter (Probit regression) nor the share of exports on sales (Tobit regression); other innovation variables (such as the importance ascribed to innovations by the firms and participation in external R&D labs) instead exert a positive and significant influence.

In a study based on a sample of more than 1000 UK manufacturing firms, Wakelin (1997, 1998) discriminates between innovators and non-innovators by using the SPRU database on the significant innovations introduced and used in the UK: because innovations do not derive exclusively from R&D, the indicators that can be obtained through their measurement are more comprehensive than those based on R&D. Wakelin then uses a set of firm variables (size, number of produced innovations, capital intensity and labor costs) and industry variables (number of produced and used innovations, R&D intensity) to explain both the probability to export and the export intensity of the firms. The results show that, in general, the size– export share relationship is 'inverted U-shaped' but the export behavior of innovating and non-innovating firms is different, since the former (which, on average, are more export oriented) rely less on labor cost advantages and more on capital intensity. The number of innovations at firm level does not raise the export performance of innovating firms, while industry technology variables significantly affect the probability to export of non-innovating firms.

A handful of studies have also analyzed the relationship between technology and international trade for the developing countries. Dasgupta and Siddharthan (1985) found that Indian exports consist largely of standardized goods with a low skill and technological content. In a study consisting of 100 engineering and 40 chemical firms, Lall (1986) found R&D expenditure (and not its intensity) to be significant, with a negative sign for engineering firms

firms and Indian pharmaceutical firms are much higher than the firms in other industries.

As discussed in the introductory chapter, the liberal policies (followed since 1991) and the threat arising thereupon from the upcoming patent era has posed a challenge and at the same time offered excellent opportunities to the domestic industry to enhance their technological capability. In the short run Indian entrepreneurs cannot be expected to go for creative innovations, which requires foresighted visions, cumulative technological ability and huge investments. However, the increased in-house R&D raises the possibility of enhanced imitation, reverse engineering, adaptation and absorption of foreign technologies. This also raises the possibility of incremental product innovations and cost-reducing process innovations for generic products. Given the lower manufacturing costs of Indian firms, any improvement in their technology is likely to push up the demand of their products abroad.

In some of the industries like, electrical equipment (including electronics and computers) generic products suddenly lose their market due to the newer product innovations. By the time such product technologies diffuse to developing economies like India, it may already be outdated. Moreover, marketing of such products is also associated by a range of highly specialized services such as instruction, installation, and repairs etc., which depend upon the proprietary knowledge originating with the manufacturer of the goods. The firm specific capabilities associated with such services make unbundling and subsequent adaptation difficult. The after sale services such as instruction, installation, repairs, maintenance etc. in the foreign markets can either be done through an unaffiliated licensee or through an affiliate (subsidiary or branch). If the services are provided through unaffiliated licensee the transaction costs are high because of the risk of losing proprietary knowledge and need of supervision of quality standards (Kumar 1990, Dunning 1993). The transaction costs can be minimized by integrating the market outlets to the organization or if the services are provided by own affiliates. This is the reason why these industries are dominated by vertically integrated firms [MNEs] that undertake R&D, manufacturing, distribution and

servicing in-house or through associated organizations [Aharoni and Hirsch (1993)].

It should be noted that the Indian subsidiaries of MNEs are able but least interested in exporting as a central policy to their parent organizations. The Indian local enterprises lack abilities to export in such industries. Thus it is not only the technological capability but the vertical integration of marketing channels (abroad) also proves to be an entry barrier for the Indian exporters in these industries.

On the contrary, in industries like pharmaceuticals generic products are equally important. At each point of time some new drugs are invented in developed countries while some patented drugs become generic. When some generic drugs become outdated some new are added to the list. Thus there is a continuous flow of generic drugs. This provides an incentive for Indian firms to invest in imitative, adaptive or absorptive innovations. Given the lower manufacturing costs of production Indian firms (both local and MNE subsidiaries) have due advantage and competitive edge over their rivals in export market. Moreover, contrary to the electrical equipment industry, the selling of pharmaceutical products does not require any after sale services. Thus even without vertically integrated market channel a firm can flourish. The present proposition is consistent with neo-technology theories as well as with neo-endowment theory. The above discussions are in line with our general hypothesis that the behavior of firms in different industries would be different.

4.5 OTHER DETERMINANTS OF EXPORTING

The exporting behavior of firms is also influenced by several macro-level and firm-level factors. Since all the firms in an industry are affected almost equally by the macro-level factors such as currency appreciation or depreciation, growth in foreign demand etc. The present study concerns only

with the firm level factors. Some of the important factors except in-house R&D are as follows:

4.5.1 Technology Import

The liberal technology collaboration policy provides freedom to imported technologies. As mentioned in the preceding section, any creative innovation by Indian manufacturers is a difficult proposition at least in the short run. For them investment in imported technologies is equally important. The role of imported technologies from abroad should be expected to boost export performance of Indian firms for at least two reasons. Firstly, it gives them technological capability to do so. Secondly, exporting by firms seems to be essential to earn foreign exchange to cover their payments for such technologies.

4.5.2 Advertising Intensity

As pointed out by Kumar and Siddharthan (1994), the firms from developing countries compete in international markets on the basis of price cutting and focus on the lower end of the markets or sell their products through the multinational marketing agencies. This is because they do not have enough resources to engage in non-price competition with MNEs. Yet the firms investing in international brand establishments and promotions are expected to perform better than others in the export market. Hence, a positive relationship may be expected between advertising intensity and export performance.

4.5.3 Firm Size

The export marketing literature has treated firm size as a proxy of firm resources that are considered important for venturing in the international markets. The industrial organization literature has posited a positive role of firm size in view of economies of scale in production and marketing. However the empirical findings on the relationship are mixed. Lall (1986) found firm size to be significant with positive sign in case of engineering firms but insignificant for chemical firms. Patibandla (1988) in case of Indian engineering industry

and Bonaccorsi (1992) in case of Italian industry found small and medium firms to be active in exports. Kumar (1990) found the firm size-export performance relationship to be significant with a positive sign in the case of foreign controlled firms but insignificant in case of local firms in Indian manufacturing industries. In his study for Brazilian firms, Willmore (1992) found firm size and its quadratic term to be significant with positive and negative signs respectively in explaining the probability of exporting and an opposite result while explaining export performance of exporters.

By inserting in the regressions both the size variable (sales) and its squared term, Kumar and Siddharthan (1994) found that, in general, export performance rose with firm size until an upper threshold and then decreased. As far as the size - export share relationship is concerned, a similar conclusion was reached by Bonaccorsi (1992) for Italian firms and Wagner (1995) for German firms. Economies of scale (i.e., the advantages of working at a minimum efficient size) and the amount of fixed costs required to enter foreign markets is the main factors explaining the positive impact of firm's size on export behaviour. However, the presence of an 'inverted U' relationship suggests that the export performance of medium-sized firms may be better than that of their largest counterparts. In fact, very large firms usually enjoy substantial domestic market power, so that they may be less oriented towards foreign markets.

4.5.4 Capital Investment

A higher capital investment intensity indicates a higher extent of automation, which in turn shows a more reliable production system and the existence of better quality control system. The higher the quality consciousness by firms, there would be a higher level of demand for their products from foreign markets. Thus, in general, a positive relationship may be expected between capital intensity and export intensity of firms.

4.5.5 Capital Import

Some technology is always embodied in any import of capital goods. The argument goes similar to the impact of the technology imports on the ensuing export performance of the firms. A positive relationship may be expected between capital import intensity and subsequent export performance of the firms.

4.5.6 Foreign Direct Investment

The role of foreign direct investment (FDI) in boosting export performance of firms is ambiguous. The firms having formal links with MNEs (i.e., controlling foreign ownership stakes) are generally considered to be better placed in tapping the international markets than Indian owned firms in view of their captive access to the information and marketing networks of their parent organizations (Dunning, 1993). As argued earlier, MNEs also enjoy economies of vertical integration and geographical diversity that impede the entry of local enterprises in export market. This implies that the propensity to export for the MNE subsidiaries is higher. However, it should be noted that the most of the MNE subsidiaries in India were set up primarily to tap the local market in response to import substitution program (Kumar 1987). They exported either to cover their import bills. In the recent past the strategies of the MNEs have changed. They are diversifying their manufacturing bases to countries like India to reap the benefits of abundantly available skilled manpower at low costs. Thus given their strong global market networking and captive access to decent technologies, MNE subsidiaries are likely to perform better than local enterprises in terms of export behavior. In an industry level study covering 43 Indian industries Kumar (1990) did not find a significant difference in the export performance of foreign controlled and local firms. Nonetheless, a proxy for FDI is included to examine its impact on the export behavior of firms in different industries. Further similar to R&D and profitability behaviors, export behavior of LCE and MNE firms will be examined separately.

CHAPTER 5

VARIABLE AND DATA DESCRIPTION

5.1 INTRODUCTION

A fundamental problem in the study of innovation and technical change in industry is the absence of satisfactory measures of technological efforts (Cohen and Levin, 1989). There exits no measure of innovation that permits readily interpretable cross-industry or intra-industry comparisons. Moreover, the value of innovation is difficult to assess when the innovation is embodied in consumer products (Griliches, 1979). Despite these problems, a number of alternative measures of innovative activities have been employed by the empirical researchers to analyze the relationship between innovative efforts and a variety of indicators of economic performance. The internal finance and profitability are also not free from measurement problems. Rest of the chapter is organized as follows. Different measures of innovative activities and the underlying difficulties will be discussed in section II. The measurement issues of internal finance is described in the section III. The section IV outlines the measurement of profitability. Measures of other variables are given in the section V. Section VI elaborates sources and nature of the data employed in the present study. The subsequent section provides the data description on different variables. The last section points out the merits and demerits of the data.

5.2 MEASURES OF R&D

Innovative activities can alternatively be proxied either through output or input measures. Each type of measurement is associated with some of the shortcomings. The important output measures of the innovative activities include –

total (or important) number of innovations, the sales of the new products, and total (or important) number of patents awarded. The innovation count as a measure of innovative activity suffers, among the others, from the limitation of giving equal weights to all innovations with heterogeneous economic values. The sales of new products depend also on the market size and other factors or weighted new products where weights reflect their relative sales[1].

The patent count as a measure of innovation, is subject to several problems. Firstly, patents are issued for the minor as well as major innovations. Consequently, this measure of innovation inappropriately gives equal weights to all kinds of innovations irrespective of their economic values. Secondly, many patented products and processes are never exploited commercially. Thirdly, a patent may consist of several related claims, each of which might be filed as a separate patent. Indeed, the US inventors have the tendency to bundle claims in one patent, while Japanese inventors typically file separate patents for each claim. Fourthly, the propensity to patent varies considerably across industries, which reduces the applicability in the cross-industry studies (Cohen and Levin 1989). Fifthly, the patent data is not widely available. Even where patents are available, the nature of an industry's technology and its competitive conditions tend to govern the trade-off between patenting innovations and keeping them secret. In some of the industries, patents reveal to competitors technological information that may not be possible through other means such as reverse engineering of the product etc. In such cases secrecy becomes the favored norm of technological innovations conducted by the corporate firms. By contrast, patents may be preferred where they serve as "signals" of technological competence to suppliers of capital especially, in case of small firms[2].

Most commonly employed input measures of innovative activity of firms are number of R&D personnel or the total expenditure on the R&D. Though both of these measures are intended to represent the current flow of resources devoted to

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[1] For detailed information about these measures, see, Kamien and Schwartz (1982) and Cohen and Levin (1989), among the others.

[2] For further discussion of the strength and weaknesses of patents as a measure of innovation, see Kamien and Schwartz (1982), Basberg (1987), Narin and Noma (1987), Cohen and Levin (1989) and Griliches (1990), among the others.

the generation of innovation, both are flawed. R&D employment excludes the flow of services from research equipment and laboratory materials, which may be combined with labor in variable proportions, while R&D expenditures includes the purchase of long-lived equipment that is expensed rather than capitalized under current accounting rules. Despite being a long run investment, R&D expenditures are treated as flow cost. R&D employment and expenditure data are also subject to considerable error in reporting, because the definitions used for financial reporting give firms enough flexibility in the classification of activities. R&D expenditure as a measure of innovative activity does not show the composition of the inputs used in the R&D process. Further it ignores the importance of accumulated knowledge[3]. In some of the industries firms show exaggerated figure for the R&D spending as a fashion to influence the stockholders favorably. For instance, some of the firms may classify even their additional activities such as building of permanent constructions, maintenance works etc to avail the tax concessions and the subsidies provided by the most of the governments including India. The quality of R&D personnel matters much more than the numerical strength. The works of R&D personnel are not restricted to the research activities only, sometimes (especially, during the crisis hour) they even have to contribute to the production process. This blurs the distinction between R&D personnel and other employees of a firm.

Further both input and output measures of innovation implicitly ignore the distinction between process and product innovations as well as between basic and applied research. This makes the specification of empirical model difficult. In practice, some variables that are expected to influence process innovation may be thought to have either no or different influence over the product innovation and vice versa. For instance, a firm's degree of diversification would be expected to have a stronger effect on basic research than on applied research and development (Nelson 1959). And the availability of patent protection would be expected to have a stronger effect on product R&D than on process R&D (Levin et al. 1987). Though, National Science Foundation, US, has the collection of industry

[3] Some empiricists notably Griliches (1979), have argued that the appropriate measure of innovative input is not the knowledge generated in one period, but the services of an accumulated

level aggregate data to distinguish product innovation from the process innovation. However, this kind of data is not available at the firm level. It should be noted that some of researchers [(Mansfield 1980) and (Link 1981, 1982)] have collected and analyzed a limited amount of data distinguishing basic research from the applied research and development at the firm level. Similarly, Scherer (1982, 1983, 1984) have attempted to distinguish the patents awarded for the process innovation from the patents granted for the product innovations. However, this kind of data can not even be conceived in case of developing countries like India.

The measurement of innovative effort of a firm or an industry is not limited only to the aforementioned problems. The considerable amounts of technological innovation emerge outside a firm's formal R&D set up. Some incremental innovation arose on a firm's shop floor (Hollander 1965), while some other innovations came through learning by doing [Hirsch (1952) and Liebernman (1984)]. Moreover, some of the innovations are initiated in the marketing division of the firm. Interestingly, many small firms simply have no formal R&D operation. Yet they exist in competitive equilibrium with other firms engaging in significant levels of R&D.

Despite all these shortcomings, both input and output measures of technological innovation have been employed by the numerous empirical researchers at both firm and industry level. The choice between input (especially, R&D expenditure) and output (especially, patent) has always been a matter of debate among the empiricists. Findings of some of the notable researchers (Mueller 1966, Comanor and Scherer 1969 and many others) support the input measures as satisfactory proxies for output measures. For instance, Rosenberg (1976, PP 103) noted that "reliance on [R&D] input rather than [R&D] output figures should provide no concern". On the other hand, some of the studies (McLean and Round 1978 and many others) concluded against the widely accepted view that R&D input data provides suitable proxies for R&D output.

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stock of knowledge upon which the firm draws. This accumulated stock of knowledge is referred to as R&D capital.

However, for all the practical purposes, choice of a particular measure of innovative effort depends on the ease of availability of data set.

Given the weak patent regime and the very low propensity to patent an invention among the Indian firms, the unavailability of patent is very obvious. The present study will employ R&D expenditure as the indicator of in-house innovative effort of the firms[4]. The exclusion of non- R&D reporting firms is helpful to avoid some of the complex issues regarding formal or informal mode of innovation by a firm. Moreover, available data set does not allow making any distinction either between process and product innovations, or between major or minor innovations.

5.3 MEASURES OF INTERNAL FINANCE

In the literature internal finance has been measured variously. Some of the researchers measured internal finance by cash flow defined as profit before taxes [e.g., Mueller (1967)] or profit before taxes plus depreciation and depletion charges [e.g., Lunn (1986)]. Some others used after tax profits [e.g., Morbey (1989)] or profit after tax plus depreciation and depletion charges [e.g., Grabowski (1968)] to indicate internal finance. Still some others considered profit before taxes or profit after taxes and depreciation and depletion charges as two separate variables [e.g., Guerard et al. (1987)]. The profit before taxes as an indicator of internal cash flow avoids both the corporate dividend policy and the existing tax structure. A firm that has good profits before taxes does not imply that it also has discretionary liquidity to undertake R&D investments. It is only the retained earnings and cumulative depreciation reserves make readily available internal resources to undertake additional investments in R&D.

Thus the retained earnings and depreciation and depletion charges are the two possible sources of internal resources available to the firms to undertake R&D investments. Either these two sources can be summed to find a consolidated

[4] Ideally the variable representing R&D effort should be taken in its capitalized form. However, the conversion of current expenses into capital assets requires some initial values. Thus in the absence of such values, R&D effort would be measured by R&D expenditure.

variable representing internal finance or they may be used as two separate variables indicating two different sources of internal funds. It should be noted that depreciation reserves might not be devoted for R&D activities but for capital replacement investments. This implies a consolidated variable adding retained earnings and cumulative depreciation reserves may not be an appropriate measure to indicate internal finance readily available for additional investments in R&D. Moreover, depreciation reserves and retained earnings may also affect the R&D investments in opposite directions. In fact the preliminary results of the present study noticed these two variables acting in the opposite directions (in some of the specifications) and hence nullifying their actual effect on stipulated dependent variable. Thus these two different sources of internal finances are employed as two separate variables to distinguish their effect on In-house R&D effort. As usual the retained earnings is measured as the profit-after-tax less dividend paid. The depreciation reserve is the usual cumulative depreciation reserves and depletion charges.

5.4 MEASURES OF PROFITS

Measurement of profitability is another case where both the theoretical and practical problems abound. A number of measures have been used, but each has some drawbacks. The economic concept of profit is the internal rate of return (IRR). It is the rate by which the future stream of net cash flows are discounted to their present values to equate to the initial cost of the project. The calculation of the IRR for a business firm is subject to several problems. For instance, the IRR of a project is defined with reference to its entire life. However, in actual practice, one may be interested in knowing the profitability of a firm only during a specified period of time. Moreover, data necessary to evaluate IRR is rarely available. Company accounts do not provide cash profiles. Rather, they provide data on each year's revenue, gross profits (revenue minus costs), interest, depreciation chargers on capital, taxes, and written-down book value of the firm' capital assets at the end of the period. Various measures of profitability may be calculated from these data.

The extensively used measures are return on capital employed (also known as accounting rate of profit). This is defined as (revenue – costs – depreciation charges) /capital assets. This method is also subject to many problems. First and obvious problem is related to the valuation of capital assets. Firms generally use historic cost, which is the initial cost of the capital, suitably written down to allow for the depreciation caused by usage since then. But the depreciation methods vary among firms. Depreciation charges are often determined by conventions or tax considerations, which bear little relation to the economic depreciation experienced. Secondly, accounting rate of profit (ARP) for a particular year provides only a snapshot of profitability, which may have very little relationship with economic rate of return (ERR) over a specified period. This problem may be resolved if ARP is constant over whole life of a firm. No individual project will have a constant ARP over time unless a very specific depreciation method, which ensures that the book value always equals the economic value, is used. However, a firm's ARP may be much more stable because it represents a portfolio of projects[5]. Moreover, it is not a serious problem for the present study if APR is any way related to the ERR[6]. Third problem arises due to the measurement of costs. The advertising and selling costs and R&D expenditures are treated as direct costs. In fact these expenditures, considering their long run impact, should be valued as accumulated capital costs, similar to the physical capital. The cost to the firm is not then the current expenses but the depreciation appropriate to such capital. Fourth problem is associated with the discretionary expenditures by the firms. In some of the firms owner-manager may take a larger salary than his contribution to the output would justify. Further unequal treatment of profits and salaries may also lead to bias. Lastly, profit-maximizing firms may not be seeking to maximize the return on capital employed. Rather, they may seek to maximize returns to the owners of the firm, measured by the rate of return on equity. In modern oligopolistic firms where there is divergence between ownership and management, the management is largely evaluates profitability of the firm in terms of sales rather than capital assets or equity. In fact a number of recent

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[5] For details, see for example, Stauffer (1971).

[6] Salmon (1985) empirically found a positive relationship between APR and IRR. ERR is nothing but IRR for a specified period.

empirical studies have used the return on sales. At first sight it appears that this measure does not require us to place a value to the capital but falsely. Even in this depreciation rate on capital has to be calculated. And most of the other shortcomings of ARP are equally applicable to this measurement.

Salinger (1984) and others favored stock market valuation as a better indicator of profitability than accounting based measures of profitability because of former having fewer accounting biases than later and also captures long-run effects. In fact this measure seems to be the better measure of profitability caused by innovative activities. While the indirect measures of R&D induced benefits like ARP come through a lag process. It is expected that that the changes in the stock market value of a firm should reflect (of course with some error) the expected discounted present value of the firm's entire uncertain net cash flow stream. Thus any event that causes the market to reevaluate the accumulated output of R&D efforts of the firm is likely to get reflected in full effect in the stock market immediately. Unfortunately, the unavailability of required data does not permit us to employ this measurement in the present study.

Keeping in mind the various pros and cons associated with different measures of profitability and also the availability of data set, the present study measures the profitability in terms of sales. Further, given the Indian tax structure, where unequal tax treatments are given to different categories firms, it would be much appropriate to consider profits before taxes. Thus the profitability would be measured as (Revenue -Costs – Depreciation charges – Interest charges)/ net sales. This is nothing but profit before taxes to sales.

5.5 MEASURES OF OTHER VARIABLES

5.5.1 Firm Size

There are three imperfectly correlated alternative measurements of firm size – sales, total assets and total number of employees. The use of a particular size deflator depends basically upon the nature of analysis of the study and the

availability of data. The case of total number of employees is ruled out because data at hand are available only for sales and total assets. Total assets are regarded as a stable measure of firm size. On the other hand, sales are more neutral size measure. Moreover, firms emphasize the use of sales as landmarks for budget decisions (Scherer 1965c). Further, sales are also preferred because they guarantee a high variability among firms.

In practice, sales are generally used for a short run analysis while total assets are preferred for a long run analysis as a measure of size (or size deflator). The present study covers only a few years. Thus it would be appropriate to employ firm sales as a measure of firm size or size deflator. The sales is taken as net of 'rebates and discounts' and 'excise duty and cess'.

5.5.2 Market Demand

The available data do not permit direct estimation of the market demand elasticity and hence the growth rate of sales may be used as a reflection of market demand conditions. It is usually measured by

$$G = \frac{(S_t - S_{t-1})}{S_{t-1}} \quad \cdots\cdots\cdots\cdots\cdots (5.1)$$

where,

G: Sales growth rate

S: sales is taken as net of 'rebates and discounts' and 'excise duty and cess',

And t and t-1 are time periods.

5.5.3 Marketing Efforts

The marketing efforts of firms normally include two activities - advertisement and selling promotions. Like R&D, adverting and selling expenses should be taken in the capitalized form. But due to the paucity of data, the expenditures incurred on these activities may reasonably be taken as a measure of advertising and marketing efforts by the firms.

5.5.4 Debt-Equity Ratio

Though in Chapter 2, it has strongly been argued that R&D investment is likely to be funded through internal resources rather than externally generated resources. Still to examine the effect of external sources of funds on R&D a proxy of it would be included in the regression equations. The debt- equity ratio would be a suitable measure of external sources of funds. The debt- equity ratio is simply measured as the total loans and advances (total borrowing) to the net worth of the firm.

5.5.5 Capital investment and Imported Capital Goods

While the net addition to the physical capital is the suitable measure for the capital investment, the measure of imported capital goods includes the expenses on imported capital goods and stores and spares.

5.5.6 Technology Imports

Technology import consists of technical fees or better known as lump sum payments, royalties, consulting and professional fees. Ideally, the variable representing technological imports should be taken in its capitalized form. However, in the absence of such data, the current expenses made on it would measure the technology import.

5.5.7 Import Competition

Traditionally import competition is measured by the shares of imported products in the total domestic demand of those products. Caves (1974) questioned the use of import shares in empirical studies to measure the extent of import competition. He argued that the constraint placed by imports on domestic pricing should more appropriately be considered as a function of the supply elasticity of imports. However, Pugel (1980) demonstrated a theoretical model to justify the relationship between price-cost margins and the import share. In accordance with Scherer and Huh (1992), the import pressure felt by a firm is calculated as:

$$IP_{ijt} = \mathrm{Import}_{jt} \times \frac{DMS_{ijt}}{(AS_{jt} - A\mathrm{export}_{jt})}$$

where,

IP_{ijt} : Import pressure felt by i^{th} firm in j^{th} industry in time period t,

$\mathrm{Im}\,port_{jt}$: Aggregate import by j^{th} industry in period t;

DMS_{ijt} : Domestic market share of i^{th} firm in j^{th} industry in period t;

AS_{jt} : Aggregate sales of the j^{th} industry in period t and

$A\exp ort_{jt}$: Aggregate exports of the j^{th} industry in period t.

5.5.8 Export

It is measured through the earnings by firms in foreign currencies (which are converted into the domestic currency according to the prevailing exchange rates).

5.5.9 Foreign Direct Investment (FDI)

In the absence of actual firm level data on foreign direct investment, it can be measured by a proxy. A suitable proxy for FDI may be the ratio of dividend paid in foreign currency to the total dividend payment by the firms. This measurement has obvious limitations. A firm with FDI need not necessarily be profitable. Moreover, even if it is profitable, it may not pay dividends in each year in commensurate with the profits made.

It should be noted that when analyzing the R&D behavior of a group of firms spanning over a spectrum, R&D intensity, rather than the absolute level of firm's R&D expenditures, is a more appropriate variable. When absolute figures are used, scale effects as well as invariable presence of heteroscedasticity and extreme values tend to dominate the regression equations. In order to avoid these problems, the present study will measure R&D relative to appropriate size deflators i.e., sales. On account of the same logic all of the variables, except size and those representing some ratios are deflated by firm sales. Table 5.1 briefly summarizes the variable descriptions.

Table 5.1: Variable Description

Variables	Definition	Measures
S	Sales	Net of 'rebates and discounts' and 'excise duty and cess'
R	In-house R&D effort	R&D expenditure / sales
IPT	Imported technology	Royalty plus technical fee plus professional and consultancy fee /sales
AD	Marketing effort	Advertisement plus other selling expenses
CAPM	Imported capital goods	Expenses on imported capital goods plus stores and spares /sales
CAPI	Ordinary Capital investment	Net addition to capital stock /sales
PT	Profits	Net of depreciation provision and interest but before tax
G	Sales Growth	$G = (S_t - S_{t-1}) / S_t$, where $_t$ and $_{t-1}$ are time periods
EX	Export	Earnings by firms in foreign currency/sales
DE	Debt-equity ratio	(Loans and advances) / (net worth)
IP	Import Competition	$IP_{it} = \mathrm{Import}_{jt} \times \frac{DMS_{ijt}}{(AS_{jt} - A\mathrm{export}_{jt})}$ where, DMS_{ijt} is domestic market share of ith firm in jth industry in period t; Import_{jt} is aggregate import by jth industry in period t; AS_{jt} is aggregate sales of the jth industry in period t; $A\mathrm{export}_{jt}$:aggregate exports of the jth industry in period t.
DEP	Depreciation reserves	The cumulative depreciation reserves/sales
RET	Retained Earnings	The profit-after-tax less dividend paid/ Sales
FDI	Foreign direct Investment	Dividend paid in foreign currency/Total dividend paid by the firms

Table 5.2: Classification of Industries

Industry	*Contents*
Electrical Equipment	Cables, Dry cells, Electric lamps, Other electrical machinery, apparatus, appliances, etc
Machinery	Machine tools, Textile machinery and accessories, and miscellaneous machineries
Pharmaceutical	Medicines and pharmaceutical preparations
Chemical	Basic industrial chemicals (organic plus inorganic)
Chemical products	Dyes and dyestuff, Paints, Varnishes and other allied products, and Other chemical products
\utomobile	Automobile vehicles, Automobile –Components repairs, etc.

Table 5.3: Distribution of Firms across Industries

No. of Firms / Industry	Reported	Consistently Reported	Actual sample		
			LCEs	MNEs	Total
Electrical Equip.	107	56	42	9	51
Machinery	96	63	48	13	61
Pharmaceutical	61	47	31	15	46
Chemical	51	36	29	7	36
Chemical Products	68	48	31	15	46
Automobile	58	42	35	7	42
Total	441	292	216	66	282

Table 5.4: Descriptive Statistics - Technology Intensive Industries

	All		Local		MNE	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
R	0.007	0.009	0.007	0.010	0.008	0.007
IPT	0.003	0.009	0.004	0.011	0.002	0.004
AD	0.018	0.023	0.017	0.022	0.018	0.024
CAPI	0.062	0.267	0.069	0.298	0.037	0.104
CAPM	0.019	0.051	0.020	0.055	0.015	0.034
PT	0.070	0.137	0.065	0.150	0.085	0.081
S	104.143	241.619	96.023	257.036	130.715	180.053
RET	0.033	0.125	0.032	0.138	0.037	0.061
DEP	0.258	0.356	0.278	0.399	0.191	0.124
EX	0.113	0.407	0.124	0.458	0.076	0.134
FDI	0.092	0.154	0.056	0.112	0.207	0.208
DE	1.277	3.559	1.334	4.042	1.090	0.798
G	12.262	29.992	12.218	33.438	12.408	13.629
Firms	282	282	216	216	66	66

Table 5.5:Descriptive Statistics - Machinery

	All		Local		MNE	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
R	0.006	0.007	0.006	0.007	0.007	0.006
IPT	0.005	0.015	0.006	0.017	0.004	0.005
AD	0.016	0.019	0.017	0.020	0.010	0.090
CAPI	0.060	0.283	0.068	0.316	0.028	0.083
CAPM	0.032	0.074	0.031	0.078	0.035	0.059
PT	0.076	0.147	0.064	0.151	0.120	0.120
S	83.333	117.911	82.018	122.546	88.186	99.641
RET	0.028	0.130	0.022	0.135	0.052	0.110
DEP	0.274	0.266	0.301	0.288	0.174	0.115
EX	0.181	0.815	0.215	0.915	0.055	0.068
FDI	0.112	0.147	0.083	0.129	0.220	0.161
DE	1.871	6.241	2.043	7.005	1.237	1.121
G	10.845	19.100	10.737	20.371	11.243	13.561
Firms	61	61	48	48	13	13

Table 5.6: Descriptive Statistics - Electrical

	All		Local		MNE	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
R	0.006	0.008	0.006	0.008	0.006	0.004
IPT	0.004	0.008	0.004	0.009	0.001	0.003
AD	0.019	0.024	0.019	0.024	0.019	0.024
CAPI	0.043	0.093	0.042	0.083	0.048	0.129
CAPM	0.027	0.053	0.026	0.056	0.033	0.036
PT	0.051	0.137	0.048	0.147	0.068	0.068
S	86.578	169.803	59.881	121.386	211.165	277.811
RET	0.020	0.121	0.019	0.125	0.024	0.036
DEP	0.197	0.129	0.194	0.132	0.211	0.114
EX	0.048	0.115	0.048	0.125	0.048	0.052
FDI	0.064	0.114	0.043	0.096	0.158	0.140
DE	1.030	2.239	0.980	2.443	1.263	0.721
G	12.554	20.517	12.668	22.062	12.021	10.890
Firms	51	51	42	42	9	9

Table 5.7: Descriptive Statistics - Pharmaceuticals

	All		Local		MNE	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
R	0.010	0.012	0.009	0.012	0.010	0.010
IPT	0.001	0.002	0.0002	0.001	0.001	0.004
AD	0.026	0.033	0.025	0.030	0.027	0.037
CAPI	0.050	0.137	0.063	0.162	0.023	0.050
CAPM	0.006	0.016	0.007	0.019	0.003	0.008
PT	0.065	0.085	0.066	0.096	0.063	0.0540
S	88.230	105.211	82.153	113.862	100.788	83.893
RET	0.036	0.076	0.040	0.088	0.026	0.039
DEP	0.169	0.271	0.188	0.327	0.130	0.052
EX	0.109	0.164	0.133	0.191	0.059	0.056
FDI	0.127	0.199	0.060	0.114	0.264	0.259
DE	1.001	1.096	1.043	1.298	0.915	0.446
G	15.676	12.334	16.198	13.100	14.598	7.839
Firms	46	46	31	31	15	15

Table 5.8: Descriptive Statistics - Chemical

	All		Local		MNE	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
R	0.005	0.009	0.005	0.009	0.007	0.006
IPT	0.003	0.009	0.004	0.010	0.003	0.0070
AD	0.010	0.011	0.011	0.010	0.008	0.011
CAPI	0.178	0.559	0.195	0.612	0.107	0.231
CAPM	0.018	0.065	0.021	0.072	0.007	0.0010
PT	0.090	0.198	0.091	0.219	0.088	0.047
S	85.957	125.173	90.118	137.359	68.720	46.904
RET	0.051	0.187	0.052	0.208	0.048	0.038
DEP	0.460	0.796	0.486	0.883	0.353	0.150
EX	0.093	0.170	0.104	0.187	0.048	0.051
FDI	0.051	0.096	0.030	0.078	0.136	0.115
DE	0.775	1.117	0.799	1.235	0.672	0.297
G	14.817	15.581	15.328	16.407	12.700	11.548
Firms	36	36	29	29	7	7

Table 5.9: Descriptive Statistics - Chemical Products

	All		Local		MNE	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
R	0.008	0.010	0.009	0.011	0.006	0.007
IPT	0.002	0.005	0.002	0.006	0.001	0.001
ASE	0.021	0.022	0.021	0.023	0.021	0.021
CAPI	0.035	0.207	0.045	0.251	0.038	0.085
CAPM	0.005	0.011	0.005	0.011	0.004	0.010
PT	0.080	0.150	0.077	0.175	0.086	0.077
S	88.609	102.772	63.754	80.553	139.976	123.343
RET	0.042	0.141	0.046	0.168	0.034	0.046
DEP	0.217	0.157	0.240	0.169	0.168	0.118
EXPO	0.164	0.227	0.171	0.218	0.151	0.246
FTD	0.101	0.180	0.046	0.107	0.214	0.239
DE	1.540	3.720	1.666	4.482	1.278	0.953
SG	6.918	62.648	4.676	75.513	11.877	11.977
Firms	46	46	31	31	15	15

Table 5.10: Descriptive Statistics - Automobile

	All		Local		MNE	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
R	0.008	0.010	0.008	0.010	0.010	0.008
IPT	0.004	0.007	0.004	0.008	0.004	0.005
AD	0.012	0.017	0.012	0.017	0.016	0.015
CAPI	0.031	0.074	0.027	0.077	0.050	0.053
CAPM	0.020	0.033	0.022	0.036	0.012	0.016
PT	0.057	0.074	0.051	0.074	0.086	0.066
S	205.724	537.572	204.360	568.997	212.542	345.641
RET	0.025	0.058	0.022	0.061	0.040	0.036
DEP	0.276	0.179	0.289	0.188	0.212	0.106
EX	0.059	0.063	0.058	0.061	0.059	0.073
FDI	0.083	0.146	0.064	0.121	0.177	0.213
DE	1.157	2.033	1.192	2.217	0.980	0.462
G	13.892	17.238	14.287	16.261	11.915	21.720
Firms	42	42	35	35	7	7

5.6 SOURCES AND NATURE OF DATA

The data set for the present study has mainly been drawn from an unpublished database compiled by the Reserve Bank of India (RBI), Mumbai[7]. The sample data contained 441 medium and large non-government, non-financial public limited companies engaged in In-house research and development (R&D) for at least one of the reported years over the period 1991 to 1995. The year indicates end of the financial years. These companies are distributed over fourteen 3-digit industries in which R&D is relatively important. Each of these companies is classified into a three-digit industry on the basis of the manufacturing activity accounting for at least one half of its turnover (principal product criterion). And the classification of an industry is based on the input used rather than output produced. In view of the very few firms in some of the 3-digit industries, it became essential to modify the existing classification of industries. The similar nature of the industries was regrouped into one stratum. The reclassification of 3-digit industries thus yields six broad industries such as: (a) Electrical Equipment (b) Machinery (c) Pharmaceuticals, (d) Chemical (e) Chemical Products and (f) Automobile. See Table 5.1 for the detailed contents of a particular industry. According to Pavitt (1984)'s taxonomy, machinery is the specialized supplier industry. The chemical, chemical products and automobile are scale intensive industries while the pharmaceuticals and electrical equipment are science based industries[8]. The machinery industry is most heterogeneous. The In-house engineering and R&D capabilities are instead stronger in 'specialized suppliers' which thrive on product innovations and 'scale intensive' firms

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[7] The basic source of data for the RBI is the company annual reports voluntarily supplied by them to RBI.

[8] According to Pavitt (1984)'s taxonomy In-house engineering and R&D capabilities are instead stronger in 'specialised suppliers' which thrive on product innovations and 'scale intensive' firms which, instead, focus on process innovations in order to exploit latent economies of scale. Finally, the highest commitment to R&D is recorded in 'science-based' firms.
Specialised supplier - Machine tools, Industrial machinery, Instruments
Scale intensive - Basic industrial chemicals, Domestic appliances, Motor vehicles
Science based - Pharmaceuticals, Office machinery and computers, Radio, TV and communication equipment

which, instead, focus on process innovations in order to exploit latent economies of scale. Finally, the highest commitment to R&D is recorded in 'science-based' firms.

The data on imports at the industry level is taken from the published issues [May 1996 and August 1998] of Centre for Monitoring Indian Economy (CMIE), Mumbai and is allocated to the actual sample companies according to their domestic market share in the industry. Sample companies together accounted for more than 60 percent of the paid-up capital of all the public limited companies of respective industries.

The given data set required for some refinement. Out of the 441 companies, 149 companies reported inconsistently. Some of these companies were identified either in the very pathetic financial condition or taken non-reporting companies Thus they were deleted from the sample. Further 10 companies were eliminated because of at least one of the following reasons: (a) The sales growth gone down (grew) by more than 100 percent in at least of reporting years (b) Consistently which resulted in the erosion of their net worth. These outlier companies were eliminated from the actual sample for the data analysis. The reduced sample contains 282 companies - 216 LCEs and 66 MNEs. The distribution of these companies along different industries is given in Table 5.2. The Tables 5.4 through 5.10 portrays the descriptive statistics of various industries.

5.7 DATA ADVANTAGES AND LIMITATIONS

5.7.1 Data advantage

These data have definite advantage over company published figures in that:

1. They are based on a common externally devised definition, and
2. Firms are assured of confidentiality treatment, thereby removing any incentives to inflate the figures artificially. The RBI data are

undoubtedly the best available statistics in India, it must be emphasized there are still many difficult conceptual problems and limitations.

5.7.2 Data Limitation

1. Many of the major R&D performers are conglomerates or widely diversified firms. Thus, the R&D figures reported by them is not necessarily done in the industry they attributed to.
2. Many firms perform R&D directed at processes and products used in other industries. There is significant difference between the industrial locus of a particular R&D activity, its origin, and its effect on the sales and profits.
3. The possibility of pure knowledge spillovers, the cross-fertilization of one firm's (or industry's) research program by developments occurring in other firms (industries).
4. To maintain confidentiality, the data supplier did not disclose firm names. As a consequence:
    - Data from other sources could not be matched with the given data.
    - Study was restricted to accounting based variables and measures of economic performance (stock market valuation could not be included in the performance indicators of firms).
    - Some other aspects, which add to the firms' technological capabilities such as – organizational flexibility- could not be taken into account while interpreting the results.
5. The relative shortness of the available time series and the lack of detailed industrial breakdown limit the range of questions that can be answered.
6. Because the data are for individual companies, this study can examine only the magnitude of private returns to R&D expenditures. That is, the issue of externalities- returns that

accrue to other firms – domestic or foreign firms - and to society at large and are not captured by the real investors, and

7. All of the variables are in undeflated current or historical prices.

CHAPTER 6

A FRAMEWORK FOR THE EMPIRICAL ANALYSIS

6.1 MODEL SPECIFICATION

As mentioned in the introductory chapter, the objective of the present study is to assess the importance of certain variables for determining R&D, profitability and exporting of the Indian private corporate firms in technology intensive industries. This would be a quantitative analysis for which we have chosen a single equation regression framework as the method of analysis. The discussions of literature in the Chapters 2, 3 and 4, provide the following one equation linear relationships for the estimation. The sign below a particular variable indicates its expected relationship with the dependent variable.

$$RD = f\left(\underset{+}{CAPI}, \underset{+}{CAPM}, \underset{+}{AD}, \underset{-}{S}, \underset{+}{S^2}, \underset{+}{RET_{-1}}, \underset{+}{DEP_{-1}}, \underset{-}{DE_{-1}}, \underset{+}{EX_{-1}}, \underset{-}{G}, \underset{+}{IP_{-1}}, \underset{+}{IPT}, \underset{?}{FDI}\right) \cdots\cdots (6.1)$$

$$PT = f\left(\underset{+}{CAPI}, \underset{+}{CAPM_{-1}}, \underset{+}{AD_{-1}}, \underset{+}{S}, \underset{-}{S^2}, \underset{+}{EX}, \underset{+}{G}, \underset{+}{R_{-1}}, \underset{-}{IP}, \underset{+}{IPT_{-1}}, \underset{+}{FDL_1}\right) \cdots\cdots (6.2)$$

$$EX = F\left(\underset{+}{CAPI}, \underset{+}{CAPM_{-1}}, \underset{-}{S}, \underset{+}{S^2}, \underset{+}{AD_{-1}}, \underset{+}{R_{-1}}, \underset{+}{IPT_{-1}}, \underset{+}{FDI_{-1}}\right) \cdots\cdots (6.3)$$

First of all, the above equations are estimated for the sample, which includes observations from all of the considered industries. Further, analysis is undertaken for each of the individual industries separately. Moreover, all of the relations are examined for the sub-samples LCEs and MNEs separately.

6.2 METHOD OF ESTIMATION

The conventional cross-sectional studies suffer from the weakness of measuring some of the important variables (Schmalensee, 1989). One set of such variables are the unobserved individual firm (industry) specific effects - such as managerial experiences, abilities and skills, organizational factors, and some other unobserved idiosyncracies. As a consequence, the estimated coefficients in such cross-sectional regressions may be seriously biased due to omitted variables (Maddala 1983). Moreover, if the included explanatory variables in the cross-sectional regressions may be correlated with these unobserved firm specific effects, the estimated coefficients may generally be overestimated. Panel data provides an opportunity to model for these individual firm specific effects so that omitted-variable bias can be reduced or avoided. There are various approaches, which are being suggested, to capture the heterogeneity of individual units not represented by included explanatory variables. For example, the variable intercept model (Kuh 1963), the error components model (Balsetra and Nerlove 1966), the random coefficients model (Hsiao 1974, 1975; Lindley and Smith 1972, Swamy 1971), and the fixed and random coefficients model (Hsiao 1995). The estimates derived from these different approaches can be very different and hence lead to very different inferences. The actual choice of a particular model depends basically on the availability of data, nature of analysis and the conscience of the investigator. For instance, fixed and random effects model proposed by Hsiao (1995) that requires a panel of longer time periods is not possible to apply for a data set available for the present study.

Given the data only for four years, we can reasonably assume that

(1) Parameters are constant over time, but can vary across individuals;

(2) Slope coefficients are homogeneous but intercepts are heterogeneous across individual firms.

To start with, we can write a model for the pooled cross-sectional analysis for each of the individual companies as follows:

$$Y_{it} = \alpha_i + \beta' X_{it} + \epsilon_{it}; \qquad i = 1,......,N, \quad t = 1,......,T. \qquad \cdots\cdots\cdots(6.4)$$

where, β is the vector of K regressor, excluding the intercept term; α_i is the individual firm specific effects which is taken to be constant over t, i.e, α_i represents the effects of those variables peculiar to the i^{th} individual in more or less the same fashion over the time ; ϵ_{it} represents the effects of omitted variables that are peculiar to both the individual units and the time periods. It is assumed that ϵ_{it} is a classical disturbance term which is characterized by an identically independently random variable with E $[\epsilon_{it}] = 0$, Var $[\epsilon_{it}] = \sigma_\epsilon^2$ and E $[\epsilon_{it}, \epsilon_{jt}'] = 0$ if $i \neq j$.

Here we are left with either treating α_i as fixed and different or treating α_i as random draws from a common distribution with constant mean and variance (i.e., fixed effects vs. random effects specifications). One view is that there is really no distinction in the "nature of effects". It is assumed at the outset that the effects are random. The fixed effects approach is viewed as one in which inferences are conditional on the firm specific effects in the sample. The random effects approach is viewed as one in which investigators make unconditional or marginal inferences with respect to the population of all effects.

On the one hand, random effects (RE) model may seem to be appropriate if the differences between units are regarded as random, sample size is small and the sample is selected through random draws. The RE model assumes that α_i is uncorrelated with other regressors and as a result unconditional inference is possible. If this restrictive assumption about the distribution of α_i is correct, then by using this additional information, RE model

should lead to more efficient estimators. And if assumption is incorrect then the random effects model will lead to biased estimators. Thus the actual choice depends on whether the random effects are correlated with the regressors (Mundalak 1978).

On the other hand, if individual differences reflect fundamental heterogeneity and viewed as the parametric shifts of the regression function, i.e., when sample is large enough and not drawn through randomization, the FE model seems to be reasonable. Moreover, if individual response coefficients depend on the values of the included explanatory variables, then estimation of the model parameters based on the conventional random-effects formulations can be misleading. To avoid this bias, heterogeneity among individual firms must be treated as fixed.

From a practical standpoint, the FE approach seems to be costly in terms of the degrees of freedom lost. However, treating the individual effects as uncorrelated with the other regressors as in the REM may suffer from the inconsistency due to omitted variables [Hausman and Taylor (1981) and Chamberlain (1978)]. Though α_i is unobserved, its permanency (or slow variation over time) would lead us to expect firms to observe and take it into account when deciding about various choice variables. For example, firms with more efficient management tend to take the decisions about investing in R&D more promptly and efficiently. Less efficient firms are not able to cope with adjustments in various investment policies of the firms. This has become more important in the fast changing business world. Keeping these arguments in mind, we have assumed α_i's as individual firm specific constants and followed the least squares dummy variable (LSDV) approach for the estimation of regression coefficients.

Following the usual practice, we looked for several criterions such as Breshun Pagan (1980)'s Lagrange multiplier (LM) test, Hausman (1978) test, the F-test and estimated residuals to convince our choice for LSDV models against its close competitor RE models.

The essential logic of LM test is as follows:

For

$$H_0: \ \sigma_u^2 \ = \ 0 \left(Or \quad Corr\left[W_{it}, W_{js} \right] \right) \ = \ 0.$$

$$H_1: \ \sigma_u^2 \neq 0,$$

The statistic is

$$LM \ = \ \frac{NT}{2\,(T-1)} \left[\left\{ \frac{\Sigma_i \, (\Sigma_t \, e_{it})^2}{\Sigma_{li} \, \Sigma_t \, e_{it}^2} \right\} 1 \right]^2,$$

where e_{it} is the OLS residuals from a homoscedastic, unautocorrelated, classical regression model. Under null hypothesis, LM is distributed as Chi-squared with one degree of freedom. A higher value of LM favors LSDV or RE model over OLS without dummy variable model and vice versa.

The basic idea of Hausman (1978) test is as follows:

Under the hypothesis of no correlation, both OLS in the LSDV model and GLS is consistent, but OLS is inefficient, whereas under the alternative, OLS is consistent, but GLS is not Therefore, under the null hypothesis, the two estimates should not differ systematically, and a test can be based on the difference. Hausman's Chi-squared statistic for testing whether the GLS estimator is an appropriate alternative to the LSDV estimator. The statistic is :

$$H \ = \ \left(\beta_{gls} - b_{lsdv} \right)' \ \left\{ Var\left[b_{lsdv} \right] \ - \ Var\left[\beta_{gls} \right] \right\}^{-1} \left(\beta_{gls} - b_{lsdv} \right)$$

Under null hypothesis H is asymptotically distributed as Chi-squared with K degrees of freedom. A higher value of H favors LSDV model over RE model and vice versa.

General formulation of the LSDV Model

A general formulation of the LSDV model assumes that differences across units in the unobserved firm specific effects can be captured in the differences in the intercept term. Thus in (6.4), each α_i is an unknown parameter to be estimated. Let Y_i and X_i be the T observations for the i^{th} unit, and let $\in_i$ be associated T×1 vector of disturbances. Then we may write as:

$$Y = [d_1 d_2 \cdots d_n X] \begin{Bmatrix} \alpha \\ \beta \end{Bmatrix} + \varepsilon$$

$$Y_i = i\alpha_i + X_i B + \varepsilon I$$

Where, d_i is a dummy variable indicating the i^{th} unit.

Let the NT × N matrix, $D = [d_1, d_2, \ldots, d_n]$. Then assembling all NT rows gives -

$$Y = D\alpha + X\beta + \varepsilon \qquad \cdots\cdots\cdots\cdots (6.5)$$

This is basically a classical regression model, which can be estimated by OLS with regressors in X and N columns in D, as a multiple regression with (N+ K) parameters. However, the conventional practice is to use the partitioned regression approach. The OLS estimator under this approach will be:

$$b = [X' M_d X]^{-1} [X' M_d Y]$$

$$M_d = 1 - D(D'D)^{-1} D'$$

Where,

This amounts to a least-squares regression using the transformed data $X^* = M_d X$ and $Y^* = M_d Y$. This makes the OLS estimator as:

$$b = [X^{*\prime} X^*]^{-1} X^{*\prime} Y^*$$

Therefore the regression of M_dY on M_dX is equivalent to the regression of $[Y_{it} - Y_i]$ on $[X_{it} - X_i]$, where X_i is the $K\times1$ vector of means of X_{it} over the T observations. The dummy variable coefficients can be computed through:

$$a_i = \bar{Y} - b'\bar{X}$$

The appropriate estimation of the covariance matrix for b is:

$$Est.\text{var.}[b] = V = s^2\left[X'M_dX\right]^{-1} = s^2(X'^*X^*)^{-1}$$

The disturbance variance estimation is:

$$s^2 = \frac{\sum_{i=1}^{n}\sum_{t=1}^{T}(Y_{it} - a_i - X'_{it}b)^2}{nT - n - k}$$

The estimated variance [b] may not be consistent if the variables in $X^*\times X^*$ are co-related with the specific variances, say σ_{it}. In the fashion of White's (1980), hetroscedastic corrected estimator for the OLS may have,

$$Est.Asy.\text{var.}[b_{lsdv}] = [X'^*X^*]^{-1}X^{*\prime}\hat{\Omega}X^*[X'^*X^*]^{-1}$$

Further assume that variances to be the same for all observations in the i^{th} group. Ω becomes a block diagonal matrix, in which i^{th} diagonal block is $\sigma_i^2 I$.

The essence of LSDV method is equivalent to leaving out the mean differences between firms, and taking into account only the within firm differences in estimating the parameters of interest[1].

There are some general criticisms leveled against LSDV model such as:

[1] See, Greene (1997) and Hsiao (1986), among others, for the detailed algebra of LSDV models.

1. The assumption of serially uncorrelated error term conditional on the individual effects α_i may not be true. As a consequence, estimated coefficients in LSDV model may be biased. We also employed the first differencing approach rather than LSDV model to control for firm specific fixed effects. To recognize this fact we included first order autoregressive process, into our basic model, i.e., $\epsilon_{it} = \rho\epsilon_{it-1} + \eta_{it}$ (for comptutational detail, see Greene 1997). Where η_{it} are iid, with mean zero and variance σ_u^2. However, the estimates did not improve over the LSDV estimators.

2. If variables are subject to measurement errors[2], exploiting panel data to control for the effects of unobserved individual characteristics using the standard differenced estimators (deviations from means, etc.) may result in even more biased estimates than simple OLS estimators using cross sectional data alone. This occurs because if the serial correlation of the measurement error is less than that of the true x, first differencing increases the noise-to signal ratio for the measured explanatory variable. The standard treatment for the errors-in-variables models requires extraneous information in the form of data such as instrumental variables. For example, if the measurement error, ι_{it}, is independently identically distributed across i and t and x is serially correlated, then we can use $x^*_{i,t-2}$ or $(x^*_{i,t-2} - x^*_{i,t-3})$ as instrument for $(x^*_{it} - x^*_{i,t-1})$ as long as T>3. Even the employment of instrumental-variable approach, could not improve the results. Thus we feel that our estimates of LSDV model are close to the true value.

3. The estimated coefficients may be downwardly biased. This is more or less true in the dynamic models where there is the case for downward adjustment, particularly for the investment variables. However, in a static LSDV model, like ours, the cases for downward bias of estimated coefficients are rarely noticeable. Still, to

CHAPTER 7

REGRESSION RESULTS: INTERNAL FINANCE AND R&D

7.1 INTRODUCTION

Table 7.1 presents the regression results to explain inter-firm variation in the R&D intensity across all the high technology industries. And Tables 7.2 through 7.7 provides regression results for individual industries – electrical equipment, machinery, pharmaceutical, chemical, chemical products and automobile, respectively. Column 1 in each of the tables represents results for all the firms including both LCEs and MNEs, while columns 2 and 3 indicate the results for LCEs and MNEs, respectively. Columns 1.1, 2.1 and 3.1 represent the model specifications in which relatively insignificant variables are dropped from the analysis. These specifications are basically reached through the backward stepwise regression methods where unimportant variables are dropped in a manner in which adjusted R^2 is maximized. In each of the econometric models LM test, H test and F-test (comparing pooled Vs fixed effect model) is significant. The residual sum of squares for fixed effect models is also lower than residual sum of squares of their counterparts, random effect models. These test results supports preference for the fixed effect models. Rest of the chapter proceeds as follows: The section 2 discusses inter-firm variation in the R&D across all the high technology industries. The sections 3 through 8 describe the regression results for individual industries – electrical equipment, machinery, pharmaceutical,

chemical, chemical products and automobile, respectively. The findings are summarized in the section 9.

7.2 TECHNOLOGY INTENSIVE INDUSTRIES

Table 7.1 reflects the followings: (a) None of the financial variables show any influence on ensuing the R&D efforts (R) of the firms. (b) The positively significant coefficient for capital intensity (CAPI) indicates larger inducement to R&D intensity as a result of the larger need to the degree of technique codification and to the degree of mechanization. (c) Contrary to the expectations, the size variable (S) is positively while its non-linear term (S^2) is negatively associated with R&D. It simply means that intermediate firms are more innovative. (d) A rise in the FDI seems to have positive impact on the level of R&D intensity of the firms. This observation, however, is weakly significant. (e) Sales growth shows strong negative effect on the R&D investment of firms. In general, it seems that the growing firms do not devote resources commensurately in R&D activities (R). In fact it may also be possible that due to the growing demand of their products, such firms diverted their technical manpower towards regular production activities rather than R&D. (f) Even the import competition (IP), which is expected to influence R&D activities of the firms favorably, influenced it adversely. It means that Indian firms are not able to improve the quality of their products or even reduce the manufacturing costs of their existing products to face the competition from imports. Another reason may be that imported commodities may be altogether new for Indian markets and hence it might not be affecting the markets captured by the domestic producers. (g) The other variables do not have any influence on the R&D investment of the firms.

These observations remain unchanged for the LCEs. For MNEs, the capital investment (CAPI) and import competition (IP) are also unrelated with R&D efforts. Moreover, the negative sign of the firm size (S) and positive sign of its non-linear term (S^2) indicates that R&D efforts (R) of MNE subsidiaries decline with the increase in firm size but it gets strengthened when they

become bigger. These generalizations however melt down as we move to individual industries and more to individual groups within an industry.

7.3 ELECTRICAL

Table 7.2 portrays the R&D behavioral patterns of the electrical equipment industry. The major observations are as follows. (a) Internal sources of funds are not binding to the R&D investment for firms in this industry. Moreover, the positively significant coefficient for the debt- equity ratio also contradicts the hypothesis that internal resources are a viable way to fund R&D investments. Three possible reasons appear to explain such findings. First, R&D investments in electrical industry is less risky in the sense that it is not totally sunk and hence it can be transferred to other uses easily. Second, given the worldwide boom in the demand of the electronics and computer products, lenders may not be unwilling to fund R&D needs of such industries. Third, the very low level of retained earnings in electrical industry (See Table 5.5) might be pushing the market valuation of such firms upward and facilitating easy availability of the external funding for such firms. (b) Increasing capital import intensity (CAPM) positively affected the in-house R&D intensity (R) of the firms. It reflects at least two possibilities. First, the need to the degree of technique codification and mechanization forces firms to invest in R&D. Second, firms are likely to invest in R&D to unbundle, learn, assimilate and adapt the technology embodied in the imported capital goods. (c) The firm size (S) and its square term (S^2) behave as hypothesized. It conforms that it is not the intermediate firms but larger ones that invest more in R&D. The larger firms in electrical industry are required to improve their existing products and to adapt some cost cutting devices to offset diseconomies of scale. (e) FDI seems to spur the in-house R&D efforts in the electrical industry. (f) The strongly significant negative sign for the export competition variable is an indication that the firms in this industry are not interested in exporting but looking only for the domestic markets. (g) Other variables are not important in explaining the R&D behavior of the firms.

These observations are unchanged for LCEs except that the capital import (CAPM) appears to be unrelated with R&D. Even for MNEs imported capital goods (CAPM) do not have any impact on R&D intensity of the firms. The observation regarding size and export intensity are similar to what were observed for the combined sample. The negative coefficient for export intensity is stronger for MNEs than LCEs. It is reasonable that MNES in this industry are least interested in exporting. Like LCEs, the sources of internal finances are not important in explaining R&D intensity of MNEs. Amazingly, even the debt-equity ratio appears with negative sign. It is interesting to notice different observations regarding financial variables for LCES and MNEs, particularly when their average R&D intensities are similar. This seems to be due to the very low value of standard deviation in R&D intensity across MNEs (See Table 5.2). Moreover, the negative coefficient for the debt equity ratio indicates that variability in borrowing might be affecting other investments, like physical capital rather than R&D.

7.4 MACHINERY

Table 7.3 summarizes the R&D behavioral patterns in the machinery industry. One of the sources of internal finance - cumulative depreciation reserves - affect subsequent R&D investment decisions positively. As described in the chapter 5, section 5.5, machinery industry, mainly comprises of machine tools, and industrial machinery. According to Pavitt (1984)'s classification these products come under highly innovative and specialized supplier category. As a consequence, firms devote their depreciation reserves to R&D investments for product improvement /creation rather than expanding the manufacturing facilities for the existing products. The positive coefficient for the firm size variable (S) points out that the intermediate firms are more innovative in the machinery industry. The explanation for the strong negative coefficient for sales growth (G) is that the firms do not devote resources to R&D investment in commensurate with their sales growth. FDI seems to affect R&D efforts of firms favorably.

These findings remain unaltered for the LCEs except the case that import competition (IP) appears with negative sign. The possible explanation seems to be similar to what we noted in the section 7.2. For MNEs the results are altogether different. For them it is the non-linear term (S^2) of the firm size that is important in explaining the R&D intensity and not the firm size (S) as in the case of LCEs. That is the intermediate LCEs and largest MNEs are more innovative. Retained earnings (RET) emerge as a very important determinant of R&D intensity for MNEs. The MNEs are new but profitable establishments as compared to LCEs. The debt-equity ratio and sales growth are also significantly negatively associated with R&D intensity.

7.5 PHARMACEUTICALS

Table 7.4 presents the R&D behavioral patterns in the pharmaceutical industry. The important observations are as follows: (a) The variables representing internal cash flows (RET1 and DEP1) are positive while the debt-equity ratio (DE1) representing external sources of funding for R&D is negative. These observations support the basic hypothesis that the internal cash flows rather than borrowings determine R&D intensity of the firms. (b) It is the larger firms, which invest much in R&D. (c) Capital import intensity (CAPM) and advertising intensity (ADV) induced R&D intensity. (d) Import pressure and FDI positively affected R&D investment. (e) Foreign technological collaborations seem to provide an alternative to the in-house R&D.

These observations proved to be myths as we consider LCEs and MNEs as two separate groups. For LCEs, R&D intensity increases with firm size without lining towards non-linearity. The impact of capital import intensity and advertising intensity on R&D intensity is similar to the overall industry noted earlier. Though the influence of financial variables are similar but their significance level gone down. Further, import pressure and sales growth did not appear important variables for R&D decision. More astonishingly, the

foreign technological collaborations are highly positively indicating a complementary relationship with R&D intensity.

For MNEs, the results are altogether different. Capital import intensity, advertising intensity and depreciation reserves are no longer important for R&D. In addition to the retained earnings, MNEs seem to generate funds for R&D through borrowings.

MNEs invest in R&D to produce cheaply to repeal the threat from imports. Despite lesser preference for export MNEs invest in R&D for other reasons that resulted in strong negative sign for the export pressure variable. The strong negative sign for sales growth (G) variable shows that MNEs' R&D expenditure do not rise in commensurate with the increasing sales.

7.6 CHEMICAL

It is clear from the Table 7.5 that the results for the categories ALL and LCEs are to a large extent very similar for the chemical industry. It is because of the dominance of the LCEs in the sample containing all the firms. The results for the MNEs are altogether different. The noteworthy features are as follows: (a) The FDI spurs indigenous R&D but its influence is not very significant (b) The basic source of R&D funding for LCE and MNEs are retained earnings (RT_{-1}) and borrowing (DE1), respectively (c) While capital investment intensity (CAPI) complemented, capital imported intensity (CAPM) substituted the R&D efforts of the LCEs. These variables do not appear important for MNEs. (d) The advertising intensity provides an important explanation for both LCEs and MNEs. (e) Technology import complements R&D efforts of MNEs. It does not have any say to the R&D efforts for LCEs. (f) The size is not important for R&D investment for LCEs. The larger MNEs are more innovative.

(g) The import pressure is not important for any group of firms. The export pressure is one of the determinants of the R&D investment for MNEs. However, it is weakly significant.

7.7 CHEMICAL PRODUCTS

Table 7.6 depicts the determinants of R&D for the chemical products industry. The important observations are as follows: (a) the retained earning is important, though weakly, for the LCEs only. The effects of other financial variables are similar for both LCEs and MNEs. The strongly negative sign for the variable DEP1 is an indication that an increase in depreciation reserves is not devoted to the R&D activities but elsewhere such as capital investment. The borrowings are also not meant for R&D ventures. (b) The advertising intensity is important for R&D for both LCEs and MNEs. It is more pronounced for the MNEs. (c) The capital investment intensity (CAPI), capital import intensity (CAPM) and size (S or S^2) are not important for either group of firms for their R&D investment decisions. (d) Sales growth induced R&D for MNEs only. (e) The negative and highly significant coefficient for import pressure variable for LCEs is surprising. It seems that in the era of import liberalization and facilitative atmosphere for FDI, the technology supplier MNEs are finding themselves profitable to export directly from their existing operations or operate in India rather than license technology to Indian LCEs. Further when foreign technology is unavailable, the LCEs are able to do adaptative researches. Thus indirectly import liberalization is becoming a bane for the R&D ventures of the LCEs. This argument seems to be corroborated by the observation that technology imports for the MNEs emerged as a substitute for their in-house technology developments.

7.8 AUTOMOBILE

The automobile industry provides a typical case where R&D behavior of LCEs and MNEs are not only differ but in contrast to each other (see Table

7.7). (a) While selling and marketing campaign spurs R&D expenditure of LCEs, capital investment and capital import intensities push R&D efforts for the MNEs. (b) The size is immaterial for R&D intensity to the LCEs. For MNEs R&D intensity increases with size (relationship is weak) to a certain extent then fell heavily. It implies that intermediate MNE firms worried (lukewarmly) about R&D expenditures while for their bigger counterparts it is not much important. (c) On the one hand, R&D is a strongly negatively associated with both the variables representing internal sources of funds for LCEs. On the contrary, these variables strongly and positively affected the subsequent R&D efforts for MNEs. R&D do not seem to be associated with the borrowings for LCEs. The negative coefficient for DE1 is also an indication that increased borrowings are devoted to the R&D investment for MNEs. (d) The need to export more enhanced R&D expenditure for LCEs. The competition from import forced MNEs to invest more in R&D. (e) In case of LCEs R&D is unrelated to the foreign technology collaborations while for MNEs technology imports seems to be an alternative to the in-house R&D expenditures. (f) R&D is positively associated with the sales growth for LCEs (though relationship is not very strong). On the contrary, it is negatively related for MNEs.

7.9 SUMMARY FINDINGS

The effect of financial variables do not appear significant in explaining inter-firm variation in the R&D efforts (R) of the Indian private corporate firms pertaining to the high technology Industries. This observation however becomes untrue as we move to the individual industries and individual groups. The retained earnings (RET_{-1}) appeared strongly significant in machinery, pharmaceutical and automobile industries for the MNEs and in the chemical industry for the LCEs. The cumulative depreciation reserves (DEP_{-1}) affects R&D efforts (R) in automobile industry for the MNEs and in machinery and chemical industries for the LCEs. The debt-equity ratio (DE_{-1}) is negatively associated with R&D efforts (R) for the LCEs in the pharmaceutical, chemical and chemical products industries. It has similar effect in case of electrical, automobile, machinery industries for the MNEs. On other hand, debt-equity

ratio (DE_{-1}) is positively associated with R&D efforts (R) in electrical industry for the LCEs and in pharmaceutical and chemical industries for the MNEs.

In general FDI affects domestic R&D efforts positively. This is possibly because of the three reasons. One, in recent past MNEs have started shifting their some of core R&D bases to recently industrialized developing countries like India to exploit the abundantly supplied scientific and technically skilled labor force at lower costs which in turn pushes the average R&D done in Indian industries. Second, the potential competition from FDI might have forced LCEs to enhance their R&D efforts. Third, the presence of technologically up to date MNEs also gives an opportunity to their local parts for imitative innovative efforts (like reverse engineering etc.).

In general technology imports (IPT) do not show any influence on the R&D efforts of the firms. The pharmaceutical industry is an exception where it has negative relations with R&D efforts, i.e., it provides a substitute for the in-house R&D efforts of the firms. However, separate analysis for LCEs and MNEs exhibit some different results. For LCEs, technology imports do not show any association with R&D efforts (R) except in the chemical products and pharmaceutical industries. This corroborates the view that the LCEs prefer mostly those technologies that can be employed without going for their own innovative efforts. This preference may be due to the following reasons: first, most of the Indian corporate firms experienced a slowdown in their sales and profitability and when they suddenly got the opportunity (due to changed technology import policies of the Indian Government) for foreign technology collaborations, they employed it as a panacea to recover their lost grounds. Second, due to the shortening life horizon of the products, firms want to import only those technologies that can be employed without much time lag so that at least its cost can be recouped before they become obsolete and outdated.

The positive signs for LCEs in the chemical products and pharmaceutical industries indicate that LCEs' technology imports provide an

inducement to the domestic technological innovative efforts for the firms. However, this relationship is significant only in the pharmaceutical industry. This implies at least two things: first, the imported technologies are complex and hence required own R&D to learn and subsequently introduce any new product or process in the market (new only to the concerned importer or the country). Second, given the importance of generic products in pharmaceutical industry, technology-importing enterprise would be interested in unbundling, adapting, and absorbing the imported technology so that it can use it even after the expiry of licensing period. It may also be interested to modify the technology to suit the locally available resources. The process of unbundling and learning by doing also provides an opportunity to incrementally improve the imported technologies for petty patents.

In general the technology imports for MNEs have negative influence on their in-house R&D efforts. This shows that imported technologies are substitutes for their own innovative efforts. This is mainly because of the following reasons: first, essentially being part of their parent organizations, MNEs do not have to put much effort to learn and employ the imported technologies. Second, MNEs are not worried about the technologies for the future because they will be supplied up to date technologies by their parent organizations. However, technology imports have positive (though insignificant) association with in-house R&D efforts for the chemical industry. This may due to their need to modify their imported technologies to use some of the locally available raw materials, which are generally banned in the developed countries.

In general imported capital goods (CAPM) do not exert any influence on innovative R&D of firms. However, it has mixed findings in the individual cases. For LCEs, CAPM shows positively and negatively significant associations in pharmaceutical and chemical industries, respectively. This implies that in chemical industry LCEs satisfy their technological needs merely by importing capital goods and machineries. The effect of capital goods on R&D effort of LCEs has similar interpretation as in case of technology imports. For MNEs, it is only the automobile industry where their imported machinery

and equipment have to be modified to produce the automobile component parts to suit the local traffic rules and road conditions. And there is need to do some adaptive R&D.

Import pressure does not have any say in the innovative efforts of the LCEs. It is only the MNEs that responded positively in terms of R&D to repel the threats from the growing imports. This is true particular in case of chemical products, pharmaceutical and automobile.

In general R&D efforts did not rise in response to the export competition. However, it has compelled LCEs in automobile industry and MNEs in chemical products to enhance their R&D efforts.

The size and its square term do not show any definite pattern. Initial result shows that R&D increases with firm size and decreases with its quadratic term. This finding melts down for the individual industries and specifically for the individual groups. For instance, in pharmaceutical industry R&D show an increasing relationship with firm size. In case of MNEs it appears with negative sign. In electrical industry, R&D effort decreases with firm size and increases with its quadratic term. This is true for both LCEs and MNEs. Sales growth negatively affects the innovative efforts of the firms. The only exception is the chemical product industry.

Table 7.1: R&D Equation – All Industries

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.008 (4.555)a	0.009 (4.942)a	0.008 (4.816)a	0.009 (5.302)a	0.511E-03 (0.343	-
CAPM	0.328E-03 (0.303)	-	0.352E-03 (0.298)	-	-0.674E-03 (0.786)	-
AD	0.020 (1.279)	-	0.018 (1.018)	-	0.039 (1.490)	0.040 (1.401)
S	0.150E-04 (2.258)b	0.157E-04 (2.361)a	0.238E-04 (2.826)a	0.246E-04 (2.907)a	-0.173E-04 (1.800)c	-0.899E-05 (2.804)a
S^2	-0.135E-08 (1.470)	-0.139E-08 (1.523)	-0.246E-08 (2.175)b	-0.251E-08 (2.226)b	0.353E-08 (0.617)	-
RET_{-1}	0.293E-03 (0.502)	-	0.274E-03 (0.469)	-	0.0023 (1.117)	-
DEP_{-1}	0.002 (1.064)	-	0.002 (1.083)	-	-0.007 (1.081)	-
DE_{-1}	-0.769E-05 (0.251)	-	-0.991E-05 (0.311)	-	-0.321E-03 (0.579)	-
EX_{-1}	-0.251E-03 (0.556)	-	-0.177E-03 (0.356)	-	-0.001 (1.140)	-
G	-0.300E-04 (3.106)a	-0.307E-04 (3.136)a	-0.309E-04 (3.025)a	-0.320E-04 (3.091)a	-0.441E-04 (2.820)a	-0.488 (3.237)a
IP_{-1}	-0.164 (2.232)b	-0.183 (2.533)a	-0.185 (2.184)b	-0.202 (2.424)a	0.083 (0.825)	-
IPT	-0.942E-03 (0.034)	-	0.008 (0.250)	-	-0.115 (1.529)	-0.106 (1.405)
FDI	0.002 (1.653)c	0.002 (1.704)c	-	-	-	-
F (df)	5.05 (294, 833)a	5.16 (287, 840)a	4.53 (227, 636)a	4.68 (220, 643)a	10.46 (77, 186)a	11.87 (69, 194)a
Adj. R^2	0.514	0.517	0.482	0.484	0.735	0.740
LM	393.51a	401.03a	251.48a	255.95a	181.5a	200.55a
H	29.57a	24.88a	28.45a	26.65a	38.5a	37.27a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 7.2: R&D Equation - Electrical

Indep Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.002 (0.598)	-	0.007 (1.294)	0.007 (1.480)	0.303E-03 (0.087)	-
CAPM	0.018 (1.678)c	0.020 (1.736)c	-0.003 (0.287)	-	-0.011 (0.586)	-
AD	-0.017 (0.783)	-	-0.025 (0.979)	-	-0.034 (1.005)	-
S	-0.301E-04 (1.792)c	-0.319E-04 (2.506)a	-0.310E-04 (1.360)	-0.314E-04 (2.431)a	-0.233E-04 (1.428)	-0.287E-04 (2.773)a
S^2	0.285E-07 (2.543)a	0.245E-07 (2.443)a	0.390E-07 (3.012)a	0.406E-07 (4.467)a	0.123E-07 (1.288)	0.123E-07 (1.989)b
RET_{-1}	0.006 (1.055)	-	0.004 (0.600)	-	0.003 (0.213)	-
DEP_{-1}	-0.008 (0.832)	-	-0.009 (0.842)	-	0.003 (0.164)	-
DE_{-1}	0.184E-03 (1.263)	0.292E-03 (1.980)b	0.238E-03 (1.303)	0.316E-03 (1.932)b	-0.001 (1.052)	-0.818E-03 (1.739)c
EX_{-1}	-0.015 (2.827)a	-0.012 (2.652)a	-0.010 (1.636)c	-0.009 (1.782)c	-0.022 (2.452)b	-0.023 (2.694)a
G	0.138E-04 (0.639)	-	0.948E-05 (0.350)	-	-0.334E-05 (0.066)	-
IP_{-1}	-0.202 (1.111)	-	0.071 (0.554)	-	-0.077 (0.765)	-
IPT	0.028 (0.676)	-	0.040 (0.838)	-	-0.027 (0.183)	-
FDI	0.019 (2.269)b	0.019 (2.242)b	-	-	-	-
F (df)	6.50 (63,140) a	7.47 (56, 147) a	6.06 (53, 114)a	7.24 (46, 121)a	4.19 (20, 15)a	10.11 (12, 23)a
Adj. R^2	0.631	0.64 1	0.616	0.632	0.646	0.757
LM	90.32a	107.57a	72.29a	89.79a	22.63a	21.58a
H	34.65a	37.72a	39.61a	33.39a	NA	34.34a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 7.3: R&D Equation - Machinery

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	-0.105E-03 (0.107)	-	0.142E-04 (0.014)	-	-0.0035 (0.638)	-
CAPM	0.311E-03 (0.280)	-	0.293E-03 (0.243)	-	0.001 (1.132)	-
AD	0.003 (0.121)	-	-0.723E-03 (0.027)	-	0.327 (1.936)b	0.323 (2.342)b
S	0.198E-04 (1.501)	0.189E-04 (1.649)c	0.240E-04 (1.664)c	0.222E-04 (1.798)c	-0.487E-04 (0.762)	-
S^2	-0.121E-07 (1.202)	-0.115E-07 (1.253)	-0.163E-07 (1.460)	-0.153E-07 (1.481)	0.967E-07 (1.232)	0.321E-07 (1.870)b
RET_{-1}	0.126E-03 (0.265)	-	0.131E-03 (0.274)	-	0.007 (2.117)b	0.008 (2.558)a
DEP_{-1}	0.012 (3.367)a	0.011 (3.454)a	0.012 (3.308)a	0.011 (3.359)a	-0.035 (1.481)	-0.034 (1.471)
DE_{-1}	0.351E-04 (1.206)	0.333E-04 (1.208)	0.381E-04 (1.227)	0.378E-04 (1.226)	-0.004 (2.861)a	-0.004 (2.717)a
EX_{-1}	-0.130E-04 (0.031)	-	0.855E-04 (0.185)	-	-0.814E-03 (0.842)	-
SG	-0.575E-04 (3.215)a	-0.565E-04 (3.266)a	-0.579E-04 (2.751)a	-0.562E-04 (2.813)a	-0.908E-04 (2.399)b	-0.927E-04 (3.079)a
IP_{-1}	-0.147 (1.456)	-0.146 (1.510)	-0.217 (1.944)b	-0.210 (1.993)b	0.256 (0.677)	-
IPT	0.026 (0.390)	-	0.027 (0.400)	-	0.093 (0.397)	-
FDI	0.559E-02 (1.508)	0.006 (1.639)c	-	-	-	-
F (df)	3.14 (73, 170)a	3.52 (67, 176)a	2.88 (59, 132)a	3.34 (53, 138)a	2.47 (24, 27)a	3.73 (18, 33)a
Adj. R^2	0.391	0.410	0.368	0.393	0.409	0.491
LM	48.71a	57.16a	37.45a	40.95a	11.15a	10.75a
H	38.13a	34.64a	35.49a	32.65a	33.71a	35.70a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 7.4: R&D Equation - Pharmaceutical

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.001 (0.385)	-	0.470E-03 (0.201)	-	-0.697E-03 (0.153)	-
CAPM	0.096 (2.583)a	0.099 (2.704)a	0.091 (2.494)a	0.092 (2.556)a	0.096 (0.790)	-
ADS	0.059 (1.640)c	0.058 (1.630)c	0.055 (1.072)	0.055 (1.056)	0.025 (0.568)	-
S	-0.576E-05 (0.114)	-	0.836E-04 (1.437)	0.124E-03 (5.161)a	-0.350E-04 (1.046)	-0.455E-04 (2.605)a
S^2	0.111E-06 (1.608)c	0.100E-06 (2.328)b	0.553E-07 (0.858)	-	-0.973E-08 (0.187)	-
RET_{-1}	0.035 (2.069)b	0.036 (2.074)b	0.023 (1.245)	0.024 (1.291)	0.082 (3.890)a	0.090 (4.763)a
DEP_{-1}	0.014 (1.881)c	0.014 (1.925)b	0.008 (1.097)	0.009 (1.163)	0.029 (0.719)	-
DE_{-1}	-0.492E-03 (3.547)a	-0.498E-03 (3.631)a	-0.515E-03 (3.782)a	-0.518E-03 (3.823)a	0.002 (1.570)	0.003 (1.949)b
EXP_{-1}	-0.007 (0.794)	-	-0.017 (1.509)	-0.017 (1.593)	-0.012 (1.602)	-0.018 (3.093)a
SG	-0.154E-04 (0.429)	-	-0.118E-04 (0.309)	-	-0.152E-03 (2.626)a	-0.121E-03 (2.355)b
IP_{-1}	2.043 (1.733)c	2.152 (2.160)b	0.195 (0.129)	-	0.906 (2.069)b	0.957 (2.697)a
IPT	-0.466 (2.400)a	-0.471 (2.413)a	8.093 (2.477)a	8.328 (3.199)a	-0.139 (1.284)	-0.113 (1.340)
FDI	0.003 (1.462)	0.003 (1.402)	-	-	-	-
F (df)	7.29 (58, 125)a	8.05 (54,129)a	6.63 (42, 81)a	7.61 (38, 85)a	20.98 (26, 33)a	28.25 (21, 38)a
Adj. R^2	0.666	0.675	0.658	0.671	0.898	0.907
LM	61.37a	67.23a	37.77a	35.90a	41.79a	42.17a
H	37.87a	38.54a	31.81a	30.49a	34.04aaa	41.36a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 7.5: R&D Equation - Chemical

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.010 (9.061)a	0.010 (9.258)a	0.010 (8.911)a	0.010 (8.725)a	-0.008 (1.728)c	-
CAPM	-0.020 (6.603)a	-0.021 (6.670)a	-0.017 (6.371)a	-0.020 (6.234)a	0.082 (0.265)	-
ADS	0.009 (0.144)	-	0.014 (0.188)	-	0.447 (0.951)	-
S	-0.227E-05 (-0.146)	-	-0.573E-05 (0.361)	-	-0.753E-03 (0.724)	-
S^2	-0.402E-09 (0.028)	-	0.418E-09 (0.029)	-	0.312E-05 (0.918)	0.366E-06 (2.629)a
RET_{-1}	0.011 (3.649)a	0.011 (3.651)a	0.012 (3.837)a	0.019 (3.889)a	0.025 (0.448)	-
DEP_{-1}	0.002 (2.237)b	0.002 (2.269)b	0.002 (3.368)a	0.002 (2.110)b	-0.008 (0.129)	-
DE_{-1}	-0.001 (1.907)b	-0.001 (1.878)c	-0.001 (2.024)b	-0.984E-03 (1.621)c	0.014 (2.244)b	0.013 (2.219)b
EXP_{-1}	0.003 (0.438)	-	-0.003 (0.207)	-	0.070 (1.926)c	0.070 (1.922)c
SG	-0.730E-04 (2.704)a	-0.673E-04 (2.763)a	-0.818E-04 (2.940)a	-0.843E-04 (3.377)a	-0.598E-04 (0.478)	-
IP_{-1}	-0.078 (0.744)	-	-0.116 (1.096)	-0.142 (2.072)b	0.416 (0.663)	-
IPT	-0.011 (0.384)	-	-0.005 (0.175)	-	0.333 (1.816)c	0.317 (1.809)c
FDI	0.010 (1.872)c	0.01 (2.265)b	-	-	-	-
F (df)	14.14 (48,95)a	16.92 (42, 101)a	18.12 (40, 75)a	21.95 (35, 80)a	1.15 (18, 9)	3.92a (10, 17)
Adj. R^2	0.815	0.824	0.856	0.864	0.089	0.415
LM	65.91a	83.54a	60.21a	74.58a	0.25	23.74a
H	39.33a	35.32a	38.62a	37.17a	NA	21.83a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 7.6: R&D Equation: Chemical Products

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	-0.003 (0.527)	-	-0.0035 (0.534)	-	0.008 (0.474)	-
CAPM	-0.013 (0.216)	-	-0.008 (0.091)	-	-0.047 (0.870)	-
ADS	0.120 (2.020)b	0.118 (2.199)b	0.140 (1.847)c	0.138 (1.983)b	-0.103 (1.670)c	-
S	0.111E-04 (0.569)	-	0.691E-05 (0.180)	-	-0.189E-04 (0.859)	-
S^2	-0.163E-07 (0.599)	-	0.445E-08 (0.074)	-	0.531E-07 (1.294)	-
RET_{-1}	0.009 (1.700)c	0.009 (1.733)	0.012 (1.596)	0.012 (1.592)	-0.005 (0.455)	-
DEP_{-1}	-0.024 (1.832)c	-0.021 (1.682)c	-0.035 (1.703)c	-0.035 (1.664)c	-0.009 (0.958)	-
DE_{-1}	-0.452E-03 (2.177)b	-0.453E-03 (2.233)b	-0.569E-03 (2.182)b	-0.355E-03 (2.133)b	-0.715E-04 (0.086)	-
EXP_{-1}	-0.012 (1.593)	-0.012 (1.582)	-0.016 (1.610)	-0.016 (1.632)c	0.020 (2.643)a	0.018 (2.571)a
SG	0.382E-05 (0.434)	-	0.942E-05 (0.455)	-	0.420E-04 (2.337)b	0.334E-04 (2.223)b
IP_{-1}	-1.011 (1.837)c	-1.004 (2.336)b	-2.216 (1.875)c	-1.987 (2.198)b	1.255 (2.376)b	1.260 (2.460)a
IPT	0.202 (0.983)	-	0.267 (1.160)	0.265 (1.189)	-2.209 (2.712)a	-2.063 (2.686)a
FDI	-0.735E-03 (0.501)a	-	-	-	-	-
F (df)	2.63 (58, 125)a	3.11 (51, 132)a	2.11 (42, 81)a	2.52 (37, 86)a	6.09 (26, 33)a	10.41 (18, 41)a
Adj. R^2	0.341	0.370	0.274	0.313	0.692	0.742
LM	20.59a	24.33a	10.20a	11.50a	6.96a	29.57a
H	36.96a	32:72a	32.77a	31.24a	39.04a	31.74a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 7.7: R&D Equation - Automobile

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	-0.002 (0.152)	-	-0.003 ((0.165)	-	0.020 (2.311)b	0.025 (2.869)a
CAPM	0.033 (0.607)	-	0.036 (0.559)	-	0.075 (1.880)c	0.090 (2.340)b
ADS	0.083 (0.927)	-	0.107 (0.927)	-	-0.079 (1.188)	-
S	0.191E-05 (0.268)	-	0.467E-05 (0.617)	-	0.141E-04 (1.020)	0.185E-04 (1.428)
S^2	0.689E-09 (0.784)	-	0.447E-09 (0.480)	-	-0.198E-07 (2.463)b	-0.230E-07 (3.041)a
RET_{-1}	-0.013 (0.945)	-	-0.014 (1.017)	-	0.105 (3.753)a	0.097 (3.506)a
DEP_{-1}	-0.015 (0.889)	-	-0.017 (0.905)	-	0.062 (2.585)a	0.062 (2.550)a
DE_{-1}	0.794E-04 (0.430)	-	0.2292E-04 (0.143)	-	-0.007 (1.875)c	-0.008 (2.641)a
EXP_{-1}	0.023 (2.449)a	0.022 (2.571)a	0.036 (2.743)a	0.031 (2.597)a	-0.004 (0.558)	-
SG	-0.323E-04 (1.007)	-	-0.296E-04 (0.673)	-	-0.751E-04 (2.488)b	-0.676E-04 (2.711)a
IP_{-1}	-0.258 (1.762)c	-	-0.308 (2.028)b	-	0.319 (2.032)b	0.308 (2.081)b
IPT	-0.033 (0.494)	-	-0.014 (0.179)	-	-0.167 (2.127)b	-0.165 (2.114)b
FDI	0.005 (1.525)	0.006 (1.891)b	-	-	-	-
F (df)	3.18 (54, 113)a	4.06 (43, 124)a	2.69 (46, 93)a	3.61 (35, 104)a	17.45 (18, 9)a	22.21 (16, 11)a
Adj. R^2	0.414	0.440	0.359	0.397	0.916	0.926
LM	33.07a	48.12a	22.78a	31.35a	9.07a	11.32a
H	34.84a	30.24a	33.52a	30.05a	NA	NA

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

CHAPTER 8

REGRESSION RESULTS: R&D AND PROFITABILITY

8.1 INTRODUCTION

Table 8.1 presents the impact of R&D on subsequent profitability of the technology intensive industries. And Tables 8.2 through 8.7 regression results for the individual industries - presents the regression results based on the fixed effect models for the technology intensive industries - electrical, machinery, pharmaceutical, chemical, chemical products and automobile, respectively. Column 1 in each of the tables represents results for all the firms including both LCEs and MNEs. Similarly, columns 2 and 3 indicate the results for LCEs and MNEs, respectively. The Columns 1.1, 2.1 and 3.1 represent the model specifications in which relatively insignificant variables are dropped from the analysis. These specifications are basically reached through the backward stepwise regression methods where unimportant variables are dropped in a manner in which adjusted R^2 is maximized. In each of the econometric models LM test, H test and F-test (comparing pooled Vs fixed effect model) is significant. The residual sum of squares for fixed effect models is also lower than residual sum of squares of their counterparts, random effect models. These test results supports preference for the fixed effect models. Rest of the chapter proceeds as follows: The section 2 discusses inter-firm variation in the R&D across all the high technology industries. The sections 3 through 8 describe the regression results for individual industries - electrical, machinery, pharmaceutical, chemical, chemical products and automobile, respectively. The summary findings are given in the section 9.

8.2 TECHNOLOGY INTENSIVE INDUSTRIES

Table 8.1 reflects the followings: (a) Neither the In-house R&D efforts nor technology imports affect the profitability of either group of the firms. This is plausibly because one-year period is not sufficient for technological activities to show any influence over profitability of firms. (b) The effect of size is crucial on the profit intensity of the firms. Profitability of both the LCEs and MNEs increases with firm size and declines thereafter. This observation supports the conventional argument that increasing economies of scale associated with firm size raised profit intensity initially. However, with the on set of diseconomies of scale, it declines. (c) Liberal imports eat into the profitability of Indian high technology intensive corporate firms. This effect however is stronger for MNEs. This observation suggests that recent liberalization is able to reduce the monopoly power enjoyed by the MNEs under high tariff walls. (d) Among the other variables, capital investment intensity shows the positive association with the profitability of the LCEs. It implies that it is the investment in the existing technologies that are more important for the LCEs. Sales growth (G) provides an important explanation for the profitability for the MNEs. Increasing sales growth is generally interpreted as an increase in capacity utilization by the firms. The generalizations prove to be misleading as we approach to individual industries.

8.3 ELECTRICAL

Table 8.2 outlines the effect of technological activities and other variables on the profit intensity of electrical industry. (a) It is the prior investment in the R&D activities (R_{-1}) that determines the profitability. (b) The firm size (S) and its square (S^2) appear consistent with the hypothesis. However these observations are true only for the profitability of LCEs. For MNEs the coefficients for these variables are statistically not different from zero. (c) The capital investment and advertising are very important in explaining the profitability of the MNEs only. (d) The sales growth (G)

enhances profitability of both the groups significantly. (e) In contrary to the general beliefs, the liberal imports (IP) do not have any impact on the price-cost margins for either group of the firms in the electrical equipment industry. (f) The highly significant negative coefficient for the export variable (EX) for the MNEs may be interpreted that these firms are interested in Indian markets and not in exporting from their Indian operations.

8.4 MACHINERY

Table 8.3 presents the regression results for the profit equation for the machinery industry. The major findings are as follows: (a) R&D investment (R_{-1}) by LCEs provided an important explanation for their profitability in the subsequent period. (b) Contrary to the general expectations, it is the very large size (S^2) that affected the profitability of the firms. (c) Sales growth (G) also provides an important explanation for the profitability of the firms. These variables are however significant only for the LCEs. (d) The capital goods import ($CAPM_{-1}$) adversely affected the profitability of the firms. This may be due to two reasons: Firstly, the production costs becomes costlier as consequence of higher import content and Secondly, the one period lag is too short to translate manufacturing capability generated through imported capital goods into profitability. None of the explanatory variables except exporting (EX) are important for the profitability of the MNEs. The idiosyncratic individual firm specific effects matter more for their profitability. The negative sign for the coefficient for exporting variable (EX) corroborates the view that their production is not meant for exporting but domestic markets.

8.5 PHARMACEUTICAL

Table 8.4 explains the determinants of profitability in the pharmaceutical industry. The important results are as follows: (a) R&D efforts (R_{-1}) and technology imports (IPT_{-1}) do not exhibit any relationship with subsequent profitability of the firms. (b) The impact of firm size (S) and its

non-linear term on profitability is in conformity with the hypothesis. (c) The sales growth (G), export (EX) and import pressure (IP) also provide important explanations for the inter-firm variation in the profitability in the pharmaceutical industry. All of these observations however do not remain completely intact for the separate analysis for the LCEs and MNEs. For instance, the firm size (S) variable is important for both the LCEs and the MNEs but its non-linear relationship (S^2) is significant only for the MNEs. The quadratic term (S^2) is not statistically different from zero for the LCEs. The export (EX) and sales growth (G) are important only for the LCEs. Moreover advertising intensity (AD_{-1}) also appears positively significant for the LCEs. On the other hand, import pressure (IP) and technology imports (IPT_{-1}) are important only for MNEs.

8.6 CHEMICAL

Table 8.5 explains the profit behavior of chemical industry. The major findings are as follows: (a) The R&D efforts (R_{-1}) and technology imports (IPT_{-1}) do not appear to have any relationship with profitability. (b) The effect of firm size (S) and its non-linear term (S^2) appear in accordance with the hypothesis. (c) The capital investment (CAPI) and exporting (EX) provide important explanations for inter-firm variation in the profitability in the chemical industry. (d) The advertising intensity (AD_{-1}) shows negative relationship with profit intensity (e) Contrary to the expectations, the import pressures (IP) and FDI have positive influence on the profitability of the firms in the chemical industry.

The results for the LCEs remain consistent with the results for the chemical industry as a whole. The separate results for the MNES differ in two respects. (a) The ensuing impact of R&D investment on profit intensity is strongly positive for the MNEs. (b) The coefficient for the technology import intensity (IPT_{-1}) for the MNEs is significant. However its negative sign is amazing.

8.7 CHEMICAL PRODUCTS

Table 8.6 explains the profit behavior of firms in the chemical products industry. (a) The in-house R&D efforts (R_{-1}) and technology imports (IPT_{-1}) are important for either group of firms for their profit intensity. (b) The capital investment intensity provides an important explanation for profitability for both categories of firms. However, its impact is stronger for the MNEs. (c) As expected FDI depressed the profit intensity of the firms in the industry. The results for the LCEs and the MNEs differ in respect of the following: (a) The advertising intensity (AD_{-1}) affects profit intensity of the MNEs adversely. It is statistically not different from zero for the LCEs. Explain (b) Sales growth (G) shows positive relationships for MNEs while for LCEs it amazingly negative. (c) The exporting (EX) and import pressure (IP) have strong positive impact on the price-cost margins of the MNEs. Their impact on the LCEs is negligible.

8.8 AUTOMOBILE

Table 8.7 depicts the profit behavior of the private corporate firms in the automobile industry. The major findings are as follows: (a) It is the technology import intensity (IPT_{-1}) rather than the R&D efforts (R_{-1}) are important in explaining the inter-firm variation in the profit intensity for the LCEs. In contrast technology import intensity (IPT_{-1}) is statistically not different from zero for the MNEs. Moreover, the coefficient for the R&D efforts (R_{-1}) appears to be significant but with negative for the MNEs. (b) The Capital investment intensity (CAPI) and the capital import intensity ($CAPM_{-1}$) are significant with negative sign for LCEs. These variables do not have any impact on the profitability for the MNEs. (c) The firm size (S) and its non-linear term (S^2) confirm the expected relationships with profitability for both the LCEs and the MNEs. Similarly, sales growth (G) also emerges significant for both the groups with expected signs. (d) The import pressure (IP) imposes the price discipline for both the LCEs and the MNEs. Similar is the case for the FDI. It has raised the price competitiveness in this industry. (e) Exporting (EX) increases the profitability of the MNEs only.

8.9 SUMMARY

In general R&D effort and technology import do not have any influence over the profitability of firms. However, in some of the industries (machinery and pharmaceutical) R&D effort positively and significantly explains the profitability of LCEs. On other hand, similar is true for MNEs only in the chemical industry. The significantly negative coefficient for the automobile industry for the MNE has following implications: (a) MNEs' R&D is not targeted to the Indian markets. (b) Their investment in the R&D has still not started yielding the benefits. Prior Technology import affected the profitability of the LCEs positively only in the automobile industry. It has similar effect for the MNEs in the pharmaceutical industry.

The competition from increasing imports affected the profitability of Indian firms negatively. In other words the import competition imposes market discipline upon the Indian enterprises. This effect is particularly significant in case of MNEs. For individual industries, the negative impact of import competition is equally pervasive for the LCEs and MNEs in Automobile industry. It has similar impact for the MNEs in the pharmaceutical industry. It is amazing to note that import pressure has increased the price-cost margin for both LCEs and MNEs in the chemical industry. This is probably because of the following reason. Most of the companies import a substantial part of the raw materials from abroad. The reduction in their import bills due to the heavy downslide in the import duties is reflected through profitability. The chemical products industry has similar findings for the MNEs.

The impact of FDI is not noticeable except in the case of automobile and chemical industries. In chemical industry it appeared with positive sign while in the automobile it has negative sign. This implies that in chemical industry MNEs are able to differentiate their products and charge higher prices vis-à-vis their local parts. The same is not possible in the automobile industry.

In some of the industries (e.g., chemical) both LCEs and MNEs gained from their exports. In others (e.g, Pharmaceutical) only LCEs boosted their profits from exporting. In industries like automobile and chemical products, only MNEs benefited from their exports. The significantly positive coefficient for MNEs in machinery and electrical equipment indicate that they are not interested in exporting but to the local markets.

The marketing effort positively affected the profitability of LCEs and MNEs in the Pharmaceutical and electrical industry respectively. Capital investment affects the profitability of firms positively. This is true for the LCEs as well as MNEs in the chemical, chemical products and electrical equipment industries. The capital import has similar influence for MNEs in the chemical products industry.

The profitability of the firms increased with firm size and decreased with its quadratic term. This pattern is almost true in each of the industries except machinery in which it is the largest MNEs that are profitable. The sales growth affected the profitability of LCEs in each of the industries except chemical and chemical products. Except pharmaceutical, the profitability of the MNEs increased in all the industries.

Table 8.1: Profit Equation - Technology Intensive Industries

Indep Var.	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.176 (3.519)a	0.172 (3.447)a	0.187 (3.665)a	0.180 (3.517)a	0.009 (0.288)	-
$CAPM_{-1}$	-0.007 (0.983)	-	-0.010 (1.413)	-	0.114 (0.719)	-
AD_{-1}	-0.385 (1.132)	-	-0.382 (0.959)	-	-0.490 (1.119)	-
S	0.307E-03 (5.116)a	0.293E-03 (5.406)a	0.339E-03 (4.203)a	0.312E-03 (4.325)a	0.491E-03 (3.644)a	0.453E-03 (3.491)a
S^2	-0.343E-07 (4.287)a	-0.332E-07 (4.364)a	-0.387E-07 (3.582)a	-0.360E-07 (3.535)a	-0.203E-06 (3.173)a	-0.181E-06 (3.046)a
EX	-0.003 (0.345)	-	0.002 (0.273)	-	-0.043 (0.985)	-
G	-0.162E-03 (0.752)	-	-0.242E-03 (1.099)	-	0.814E-03 (2.954)a	0.826E-03 (3.103)a
R_{-1}	-0.400 (0.462)	-	-0.345 (0.385)	-	-1.388 (0.897)	-
IP	-1.614 (2.238)b	-1.578 (2.258)b	-1.399 (1.635)c	-1.358 (1.631)c	-2.537 (2.844)a	-2.241 (2.700)a
IPT_{-1}	-0.170 (0.572)	-	-0.181 (0.575)	-	-0.083 (0.104)	-
FDI_{-1}	-0.023 (1.128)	-	-	-	-	-
F (df)	4.38 (292, 835)a	4.48 (285, 842)a	4.52 (225, 638)a	4.62 (219, 644)a	3.46 (75, 188)a	3.56 (69, 194)a
Adj. R^2	0.467	0.469	0.479	0.481	0.412	0.414
LM	226.74a	266a	203.06a	205.07a	50.27a	58.35a
H	36.08a	28.18a	32.44a	26.14a	34.05a	27.11a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 8.2: Profit Equation - Electrical

Indep Var.	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.057 (1.460)	-	0.089 (1.159)	-	0.067 (3.548)a	0.069 (4.949) a
$CAPM_{-1}$	-0.229 (1.759)c	-0.264 (2.063)b	-0.191 (1.384)	-	-0.132 (0.655)	-
AD_{-1}	-0.485 (0.851)	-	-0.637 (1.022)	-	1.301 (3.863)a	1.241 (3.933) a
S	0.533E-03 (1.816)c	0.654E-03 (3.002)a	0.370E-03 (0.760)	0.858E-03 (2.566)a	0.813E-04 (0.416)	-
S^2	-0.310E-06 (2.257)b	-0.371E-06 (2.776)a	-0.379E-06 (1.798)c	-0.473E-06 (2.380)a	0.399E-07 (0.426)	-
EX	-0.117 (0.914)	-	-0.058 (0.420)		-0.607 (4.683)a	-0.635 (5.550) a
G	0.001 (5.906)a	0.001 (5.029)a	0.001 (5.247)a	0.001 (4.283)a	0.001 (3.875)a	0.001 (3.747) a
R_{-1}	1.812 (2.423)a	1.841 (2.514)a	1.602 (2.088)b	1.608 (2.111)b	1.763 (1.059)	-
IP	0.337 (0.167)	-	4.800 (1.130)	-	-1.446 (1.242)	-
IPT_{-1}	-0.870 (0.822)	-	-0.614 (0.570)	-	-2.388 (1.250)	-
FDI_{-1}	0.037 (0.644)	-	-	-	-	-
F (df)	21.38 (61, 142)a	23.26 (55, 148)a	20.99 (51, 116)a	22.97 (45, 122)a	18.38 (18, 17)a	31.31 (12, 23)a
Adj. R^2	0.860	0.868	0.859	0.856	0.899	0.912
LM	117.60a	203.76a	81.83a	166.62a	15.00a	28.36b
H	32.69a	28.60a	33.02a	27.04a	NA	27.30

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 8.3: Profit Equation - Machinery

Indep Var.	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.042 (0.918)	-	0.049 (1.067)	-	-0.313 (1.451)	-0.319 (1.422)
$CAPM_{-1}$	-0.009 (1.671)c	-0.013 (2.375)a	-0.010 (1.769)c	-0.011 (1.772)c	-0.304 (1.462)	-0.271 (1.374)
AD_{-1}	-0.007 (0.005)	-	0.468 (0.379)	-	-10.163 (1.476)	-10.164 (1.554)
S	-0.841E-03 (2.424)a	-0.001 (2.472)a	-0.843E-03 (2.124)b	-0.001 (2.484)a	-0.688E-03 (0.636)	-
S^2	0.625E-06 (2.247)b	0.781E-06 (2.137)b	0.568E-06 (1.779)c	0.814E-06 (2.077)b	0.728E-06 (0.545)	-
EX	-0.001 (0.172)	-	0.005 (0.667)	-	-0.083 (2.045)b	-0.081 (2.039)b
G	0.001 (1.743)c	0.002 (1.997)b	0.002 (1.750)c	0.002 (1.945)b	0.001 (1.276)	0.001 (1.153)
R_{-1}	1.574 (0.940)	-	2.698 (1.934)b	2.698 (1.945)b	-9.758 (1.482)	-9.701 (1.493)
IP	-2.084 (0.520)	-	-3.082 (0.684)	-	4.287 (0.787)	-
IPT_{-1}	-0.072 (0.231)	-	-0.216 (0.625)	-	1.822 (0.560)	-
FDI_{-1}	-0.022 (0.400)	-	-	-	-	-
F (df)	4.48 (71, 172)a	5.07 (64, 179)a	5.66 (57, 134)a	6.27 (52, 139)a	1.48 (22, 29)a	2.03 (18, 33)a
Adj. R^2	0.504	0.518	0.582	0.590	0.171	0.266
LM	54.21	78.69a	61.43	74.87a	0.58	0.91
H	35.34	30.69a	31.56a	34.99a	35.03a	40.88a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 8.4: Profit Equation – Pharmaceutical

Indep Var.	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	-0.043 (0.737)	-	-0.037 (0.616)	-	-0.019 (0.315)	-
$CAPM_{-1}$	0.664 (0.616)	-	1.042 (0.731)	-	0.922 (1.579)	0.923 (1.585)
AD_{-1}	0.254 (1.542)	0.241 (1.594)	0.415 (2.435)a	0.418 (2.441)a	-0.186 (0.879)	-
S	0.991E-03 (3.803)a	0.878E-03 (3.508)a	0.891E-04 (0.303)	0.233E-03 (2.597)a	0.002 (4.184)a	0.002 (4.197)a
S^2	-0.672E-06 (2.195)b	-0.539E-06 (2.021)b	0.280E-06 (0.767)	-	-0.231E-05 (2.578)a	-0.222E-05 (2.575)a
EX	0.248 (2.212)b	0.254 (2.180)b	0.392 (2.729)a	0.379 (2.963)a	0.073 (0.739)	-
G	0.947E-03 (2.160)b	0.001 (2.223)b	0.001 (2.256)b	0.001 (2.525)a	-0.400E-04 (0.060)	-
R_{-1}	0.111 (0.255)	-	0.490 (1.129)	0.774 (1.286)	-0.879 (0.664)	-
IP	-14.729 (2.015)b	-16.217 (2.327)b	0.071 (0.011)	-	-68.820 (5.095)a	-68.434 (6.461)a
IPT_{-1}	-2.474 (0.367)	-	-16.331 (1.599)	-9.320 (1.443)	22.204 (4.949)a	22.298 (5.207)a
FDI_{-1}	0.015 (0.639)	-	-	-	-	-
F (df)	3.55 (56, 127)a	3.90 (51, 132)a	3.65 (40, 83)a	4.01 (36, 87)a	5.72 (24, 35)a	8.06 (19, 40)a
Adj. R^2	0.439	0.447	0.463	0.469	0.657	0.695
LM	21.45a	23.89a	8.20a	11.65a	0.72	1.66
H	36.75a	42.78a	39.25a	30.87a	38.72a	42.21a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 8.5: Profit Equation - Chemical

Indep Var.	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.240 (4.306)a	0.240 (4.342)a	0.240 (4.242)a	0.243 (4.273)a	0.146 (8.675)a	0.145 (9.810)a
$CAPM_{-1}$	0.005 (0.036)	-	0.081 (0.667)	-	0.051 (0.063)	-
ADS_{-1}	-5.724 (3.372)a	-5.497 (3.272)a	-5.251 (3.035)a	-5.455 (3.137)a	-8.538 (2.045)b	-8.591 (2.159)b
S	0.575E-03 (1.790)c	0.511E-03 (1.756)c	0.456E-03 (1.184)	0.570E-03 (1.587)	0.004 (5.009)a	0.004 (5.311)a
S^2	-0.568E-06 (1.677)c	-0.550E-06 (1.650)c	-0.658E-06 (1.693)c	-0.658E-06 (1.673)c	-0.171E-04 (5.516)a	-0.170E-04 (5.791)a
EX	0.508 (2.883)a	0.506 (2.975)a	0.394 (2.022)b	0.337 (1.859)b	0.418 (3.845)a	0.416 (3.697)a
G	-0.343E-04 (0.060)	-	-0.532E-03 (0.918)	-	0.560E-03 (1.577)	0.575E-03 (1.614)
R_{-1}	-3.968 (1.322)	-4.034 (1.265)	-3.857 (1.214)	-4.297 (1.268)	2.329 (3.796)a	2.333 (3.796)a
IP	5.706 (1.893)c	6.253 (2.133)b	7.440 (1.959)b	5.802 (1.795)c	2.768 (1.641)	2.700 (1.778)c
IPT_{-1}	-0.987 (0.960)	-	0.474 (0.378)	-	-4.009 (5.829)a	-3.973 (7.053)a
FDI_{-1}	0.244 (1.727)c	0.247 (2.077)b	-	-	-	-
F (df)	9.04 (46, 97)a	9.92 (43, 100)a	9.36 (38, 77)a	10.46 (35, 80)a	4.52 (16, 11)a	5.26 (15, 12)a
Adj. R^2	0.721	0.728	0.734	0.742	0.676	0.703
LM	4.92b	5.88a	4.36b	6.16a	3.14c	2.59c
H	36.34a	47.00a	31.05a	30.97a	29.48a	27.34a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 8.6: Profit Equation - Chemical products

Indep Var.	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.146 (1.644)c	0.151 (1.650)c	0.156 (1.659)c	0.168 (1.709)c	1.050 (6.032)a	1.043 (6.001)a
$CAPM_{-1}$	-0.114 (0.135)	-	-0.676 (0.728)	-	1.845 (1.946)b	1.698 (1.815)c
AD_{-1}	-1.109 (0.652)	-	-1.177 (0.582)	-	-2.285 (3.476)a	-2.232 (4.758)a
S	0.113E-03 (0.323)	-	0.596E-03 (1.094)	-	-0.557E-03 (1.548)	-0.357 (1.245)
S^2	-0.193E-06 (0.560)	-	0.317E-06 (0.463)	-	0.177E-06 (0.554)	-
EX	0.070 (0.828)	-	0.016 (0.159)	-	0.185 (3.371)a	0.147 (2.881)a
G	-0.468E-03 (1.477)	-0.477E-03 (1.512)	-0.520E-03 (1.538)	-0.561E-03 (1.631)c	0.001 (3.141)a	0.001 (3.231)a
R_{-1}	0.265 (0.597)	-	0.291 (0.607)	-	-1.196 (1.441)	-
IP	5.877 (0.583)	-	-26.260 (1.544)	-	22.654 (2.511)a	19.199 (1.983)b
IPT_{-1}	-1.190 (1.643)c	-0.984 (1.556)	-1.144 (1.519)	-0.901 (1.368)	-3.584 (0.817)	-
FDI_{-1}	-0.078 (1.602)	-0.078 (1.612)c	-	-	-	-
F (df)	1.39 (56, 127)c	1.65 (49, 134)a	1.43 (40, 83)c	1.68 (33, 90)a	13.91 (24, 35)a	16.89 (21, 38)a
Adj. R^2	0.106	0.147	0.042	0.111	0.840	0.850
LM	3.92b	5.13b	1.93	2.28	6.92a	23.69a
H	24.23b	23.00a	22.86b	21.23a	NA	32.18a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 8.7: Profit Equation - Automobile

Indep Var.	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	-0.113 (2.136)b	-0.113 (2.168)b	-0.120 (2.038)b	-0.123 (2.123)b	0.075 (0.710)	-
$CAPM_{-1}$	-0.225 (1.777)c	-0.216 (1.710)c	-0.225 (1.725)c	-0.220 (1.697)c	0.376 (0.635)	-
AD_{-1}	-0.496 (0.885)	-	-0.543 (0.787)	-	-0.995 (1.013)	-
S	0.180E-03 (3.696)a	0.190E-03 (4.083)a	0.263E-03 (5.082)a	0.260E-03 (5.281)a	0.597E-03 (4.415)a	0.518E-03 (3.713)a
S^2	-0.212E-07 (3.496)a	-0.226E-07 (3.905)a	-0.316E-07 (4.847)a	-0.311E-07 (5.046)a	-0.271E-06 4.037)a	-0.233E-06 (3.302)a
EX	0.073 (0.766)	-	-0.005 (0.047)	-	0.688 (2.954)a	0.631 (3.359)a
G	0.001 (5.451)a	0.001 (5.448)a	0.001 (3.646)a	0.001 (3.690)a	0.002 (8.086)a	0.002 (7.132)a
R_{-1}	-0.120 (0.239)	-	-0.047 (0.094)	-	-3.840 (3.141)a	-3.009 (2.837)a
IP	-0.876 (2.325)b	-0.917 (2.544)a	-1.067 (3.160)a	-1.143 (3.521)a	-5.510 (4.113)a	-4.475 (3.485)a
IPT_{-1}	1.670 (2.211)b	1.710 (2.375)a	1.772 (2.050)b	1.883 (2.340)b	-0.214 (0.243)	-
FDI_{-1}	-0.076 (2.833)a	-0.074 (2.801)a	-	-	-	-
F (df)	4.78 (52, 115)a	5.17 (49, 118)a	3.73 (44, 95)a	4.11 (41,98)a	7.54 (16, 11)a	12.75 (12, 15)a
Adj. R^2	0.541	0.550	0.463	0.478	0.795	0.839
LM	40.59a	43.72a	19.61a	26.38a	2.30	7.72a
H	37.39a	36.68a	32.79a	30.16a	NA	24.99a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

CHAPTER 9

REGRESSION RESULTS: R&D AND EXPORTING

9.1 INTRODUCTION

The Table 9.1 through 9.7 presents the regression results based on the fixed effects models to explain the firm level factors that determine export performance of the firms. Each of these tables contains results based upon six modes. As in the earlier chapters, models 1 and 1.1 represent all firms. Models 2 and 2.1 represent LCEs and models 3 and 3.1 MNEs. The first model in each of these categories is based on all of the possible variables (as discussed in Chapter 4) that are likely to influence the export behavior of firms. The second model in each of the categories keeps only the significant variables. The organization of the chapter is as follows: Section 9.2 describes results of the R&D intensive-manufacturing sector. The sections 9.3 through 9.8 discuss results on the individual industries. The section 9.9 provides the summary view of the results discussed in earlier sections.

9.2 TECHNOLOGY INTENSIVE INDUSTRIES

The Table 9.1 presents the exporting behavior of firms in the R&D intensive Indian private corporate manufacturing sector. (a) The R&D efforts do not show any association with the exporting of the firms. (b) Among other variables, only the technology import intensity (IPT_{-1}) and capital goods import intensity ($CAPM_{-1}$) affect export performance of firms positively. This result

may be interpreted as follows: firstly, only the imported content of technological capabilities enables firms to face the exporting markets. Secondly, it also implies that Indian firms are interested in exporting only to recoup their expenses (in terms of scarcely available foreign exchanges) made on the imported technology and capital goods. The results for the LCEs are similar.

The foreign direct investment (FDI_{-1}) has negative impact on the subsequent export performance. This implies that FDI, more specifically, MNEs do not target their sales to the export markets but aim at tapping the local markets. The negatively significant coefficients for both the technology variables (R_{-1} and IPT_{-1}) for the MNEs also support the above viewpoint. Their R&D efforts are meant to tap the local markets rather than exporting. In most of the cases the coefficients for the individual firm specific effects appear to be significant. Other things remaining the same, it may be interpreted that export performance of firms depends heavily on their idiosyncratic factors and preferences rather than measurable variables. However, these findings do not remain intact for individual industries except the feature that individual firm specific capabilities matter for export performance.

9.3 ELECTRICAL

Table 9.2 depicts the export behavior of firms in the electrical equipment industry. The exporting behavior of firms is almost similar for both the LCEs and the MNEs. (a) None of the technology variables are important in explaining the export behavior of firms in the electrical equipment industry. (b) The exporting declines with firm size (S) but starts zooming when firms become too large. This explains the fact that MNEs import electrical equipment parts from their parent organizations to assemble and sell in the Indian markets. And only when they become larger with significant assembling capability, they also start exporting to the markets of neighboring countries. While in case of LCEs, it is only the largest firms that possess the necessary resources (strong networking to provide a range of highly

specialized services such as instruction, installation, repairs etc) to venture in the export markets. (c) The MNEs' exporting also depends on the capital goods import ($CAPM_{-1}$). This reflects the fact that exporting becomes essential for the MNEs to cover their capital goods import bill. Other variables are insignificant.

9.4 MACHINERY

The Table 9.3 describes the regression results concerning the firm level determinants of the export performance in the machinery industry. The very low level of adjusted R^2 indicates the fact that the variables considered in the models are not able to capture the exporting behavior of firms in the machinery industry. It is ironical when this industry has maximum export intensity (See Table 5.3, Chapter 5). As argued in Chapter 4, there are basically three sets of factors that determine the export performance of the firms. First, comparative advantage of a country vis-a- vis its trading partners. Second, comparative advantage of an industry vis-a-vis its counterparts in other countries. Third, competitive advantage of the firm vis-a-vis other firms in the industry. It seems that macro level factors are mainly responsible for the export performance of firms rather than factors at the firm level in machinery industry. In case of LCEs only the technology import intensity affects the exporting of firms. The R&D efforts appeared strongly significant but with negative sign for the MNEs. This is an indication that the R&D efforts of the MNEs are not targeted towards the exporting.

9.5 PHARMACEUTICAL

Table 9.4 summarizes the exporting patterns of the firms in pharmaceutical industry. (a) The innovative effort is highly significant in explaining the export behavior of each category of firms. This supports the conjecture that innovative firms are able to push forward their sales in foreign markets. (b) Export intensity increases with firm size but it starts declining

(though insignificantly) when firms become too large. This reflects that the largest firms are more interested in domestic market where they have established themselves as monopolistic giants. However, the separate analysis for LCEs and MNEs supports this observation only for the LCEs. For MNEs the impact of firm size on exporting is not different from zero.

(c) Among the other variables, imported capital goods boosts the export performance of the MNEs. For LCEs it is the investment in physical capital, which in turn expands manufacturing capability that influences their performance. The result however does not have significant statistical support The above two findings are in consistent with the emerging trend in the industry to expand manufacturing capability to supply some bulk drugs to foreign companies under some contractual agreements.

9.6 CHEMICAL

The imported technology (IPT_{-1}) and R&D efforts (R_{-1}) positively influence the export intensity of the firms in the chemical industry (See Table 9.5). However, their coefficients are statistically not very significant. The coefficients for other variables are not different from zero. The separate regressions for LCEs and MNEs are interesting. Both the technology import (IPT_{-1}) and the R&D efforts (R_{-1}) provide important explanations for exporting by LCEs. On the other hand, both the firm size and its quadratic term are very significant for the MNEs. The former has negative sign while the later has positive sign. This has similar explanation as was given in the case of electrical equipment industry. The MNEs initially produce for local markets and only when they become too large (having excess capacity and supply) they start looking for other markets. One more thing should be added to this generic explanation. Given the low manufacturing cost in India (due to the availability of cheap labor force and lackadaisical safety norms) some MNEs might have invested heavily to fulfill the needs of their parent organizations. The possible explanation for strongly negative coefficient for capital investment variable (CAPI) for the MNEs is that exports for these firms did not

rise in commensurate with investment made in physical capital. This may possibly because of the two reasons: Firstly, investment yields fruits with time lag. Secondly, additional investment is not largely targeted to the export market[1].

9.7 CHEMICAL PRODUCTS

Table 9.6 summarizes the regression results related to the exporting behavior of firms in the chemical products industry. Both the technology variables (R_{-1} and IPT_{-1}) are important in explaining the export intensity for the MNEs in this industry. This implies the followings: (a) MNEs get up to date technologies from their parent organizations to manufacture quality products acceptable to the foreign markets. (b) They are able to devise some suitable technologies to use locally available raw materials to make their production costs lower so that they could compete even in the lower segment of the international markets.

Only the firm size variables contribute significantly to the exporting of LCEs. Like pharmaceutical industry, export intensity shows a positive relationship with firm size and negative relationship with its quadratic term. This is also true for the MNEs. This has similar explanation as in the pharmaceutical industry.

9.8 AUTOMOBILE

Table 9.7 depicts the exporting behavior of firms in the automobile industry. The R&D efforts (R_{-1}) contribute to the export performance of the firms in automobile industry. However, this remains significant only for the LCEs. The intuitive reason may be that LCEs might be doing innovative effort (R_{-1}) to supply the product that must meet the required qualitatively standards

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[1] Almost fifty percent of the need of the basic industrial chemicals in India is supplied through imports. Now after liberalization, some of the exporters to the Indian market, who also had Indian subsidiaries, have started increasing additional manufacturing capability (due to low production cost) to replace their supplies from their parent organizations by their Indian subsidiaries. This implies that additional investment is targeted more towards local markets.

Table 9.1: Export Equation – Technology Intensive Industries

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.029 (1.105)	-	0.031 (1.158)	-	0.0427E-01 (0.458)	-
$CAPM_{-1}$	0.412 (1.652)c	0.414 (1.662)c	0.411 (1.627)c	0.412 (1.634)c	-0.864 (0.595)	-
S	-0.537E-04 (0.851)	-	-0.135E-04 (0.178)	-	-0.210E-03 (0.784)	-
S^2	0.847E-08 (0.945)	-	0.225E-08 (0.216)	-	0.826E-07 (0.533)	-
AD_{-1}	-1.183 (1.347)	-	-1.086 (1.087)	-	-2.146 (1.111)	-
R_{-1}	-0.789 (0.550)	-	-0.025 (0.017)	-	-12.342 (1.896)c	-11.364 (1.820)c
IPT_{-1}	9.424 (1.710)c	9.309 (1.710)c	9.911 (1.725)c	9.826 (1.723)c	-4.332 (1.957)b	-4.872 (2.149)b
FDI_{-1}	-0.131 (1.661)c	-0.134 (1.686)c	-	-	-	-
F (df)	1.95 (289, 838)	1.99 (284, 843)	1.96 (222, 641)	2.02 (217, 646)	1.81 (72, 191)	1.92 (67, 196)
Adj. R^2	0.196	0.200	0.199	0.204	0.182	0.190
LM	1.02	0.84	3.02	2.84	5.99b	12.10a
H	47.21a	47.48a	32.47a	32.48a	38.14a	33.45a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 9.2: Export Equation - Electrical

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.055 (1.700)c	0.056 (1.719)	0.006 (1.148)	0.008 (1.449)	0.021 (0.839)	-
$CAPM_{-1}$	-0.026 (0.277)	-	-0.012 (1.059)	-	0.393 (2.172)b	0.502 (2.780)a
S	-0.176E-03 (0.957)	-	-0.190E-04 (1.256)	-0.257E-04 (1.988)b	-0.388E-03 (1.898)c	-0.259E-03 (2.384)b
S^2	0.120E-06 (1.046)	-	0.320E-07 (3.079)a	0.357E-07 (3.817)a	0.206E-06 (1.902)c	0.145E-06 (2.417)b
ADS_{-1}	-0.142 (0.837)	-	0.842E-03 (0.040)	-	0.147 (0.457)	-
R_{-1}	0.520 (1.098)	-	0.050 (0.272)	-	-3.773 (1.360)	-
IPT_{-1}	-0.410 (1.133)	-	0.038 (0.805)	-	-0.429 (0.516)	-
FTD_{-1}	0.057 (1.503)	0.060 (1.599)	-	-	-	-
F (df)	31.21 (58, 145)a	35.52 (52, 151)a	6.66 (48, 119)a	7.39 (44, 123)a	4.12 (15, 20)a	5.58 (11, 24)a
Adj. R^2	0.896	0.898	0.619	0.627	0.572	0.590
LM	232.87a	235.88a	0.61	96.09a	8.44a	10.68a
H	33.81a	32.98a	58.22a	32.22a	32.75a	31.98a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 9.3 Export Equation - Machinery

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.242 (1.458)	0.255 (1.596)	0.228 (1.370)	0.233 (1.442)	-0.272 (0.337)	-
$CAPM_{-1}$	0.345 (1.239)	0.355 (1.277)	0.352 (1.254)	0.355 (1.263)	-2.111 (1.296)	-1.675 (1.122)
S	-0.001 (1.202)	-	-0.688E-03 (0.830)	-	-0.006 (1.095)	-0.003 (1.835) c
S^2	0.137E-05 (1.806)c	-	0.9945E-06 (1.406)	-	0.659E-05 (0.998)	-
AD_{-1}	-3.888 (0.687)	-	-3.790 (0.663)	-	-25.675 (0.714)	-
R_{-1}	-9.266 (0.819)	-	-3.224 (0.268)	-	-59.504 (1.979)b	-66.658 (2.190) b
IPT_{-1}	14.784 (1.773)c	14.797 (1.780)c	15.094 (1.783)c	15.101 (1.786)c	-4.774 (0.395)	-
FDI_{-1}	-0.976 (1.376)	-	-	-	-	-
F (df)	1.37 (68, 175)b	1.47 (63, 180)b	1.38 (54, 137)c	1.52 (50, 141)b	1.13 (19, 32)	1.42 (15, 36)
Adj. R^2	0.094	0.108	0.096	0.121	0.045	0.120
LM	10.85a	9.68a	10.05a	8.21a	0.02	0.03
H	25.28a	23.24a	25.11a	22.43a	2.42	2.34

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 9.4: Export Equation - Pharmaceutical

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.026 (1.479	0.024 (1.458)	0.020 (1.192)	0.020 (1.505)	-0.010 (0.072)	-
$CAPM_{-1}$	0.260 (0.907)	-	-0.079 (0.234)	-	0.500 (1.785)c	0.624 (2.302) b
S	0.326E-03 (1.386)	0.168E-03 (1.940)b	0.790E-03 (2.253)b	0.694E-03 (2.215)b	-0.273E-03 (0.915)	-
S^2	-0.235E-06 (0.685)	-	-0.782E-06 (1.677)c	-0.640E-06 (1.492)	0.512E-06 (0.923)	-
AD_{-1}	-0.113 (0.659)	-	-0.103 (0.529)	-	0.045 (0.166)	-
R_{-1}	1.643 (3.552)a	1.604 (3.902)a	1.50 (3.198)a	1.543 (3.274)a	1.875 (2.082)b	2.342 (2.829) a
IPT_{-1}	-2.672 (1.220)	-	4.085 (0.918)	-	-2.030 (0.878)	-
FDI_{-1}	-0.004 (0.484)	-	-	-	-	-
F (df)	40.71 (53, 130)a	46.21 (48, 135)a	44.09 (37, 86)a	49.34 (34, 89)a	5.03 (21, 38)a	7.30 (16, 43)a
Adj. R^2	0.920	0.922	0.928	0.930	0.589	0.630
LM	122.1a	124.34a	88.24a	83.07a	21.57a	28.11a
H	41.6a	38.88a	26.49a	27.02a	22.82a	21.07a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 9.5: Export Equation - Chemical

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.907E-03 (0.266)	-	0.005 (1.276)	-	-0.112 (5.752)a	-0.111 (6.709)a
$CAPM_{-1}$	-0.053 (0.454)	-	-0.139 (1.088)	-	0.002 (0.008)	-
S	0.111E-03 (0.393)	-	0.874E-04 (0.301)	-	-0.002 (2.073)b	-0.002 (2.890)a
S^2	-0.197E-06 (0.781)	-	-0.130E-06 (0.530)	-	0.867E-05 (1.871)c	0.852E-05 (2.276)b
AD_{-1}	0.0713 (0.099)	-	0.410E-03 (0.001)	-	-0.387 (0.095)	-
R_{-1}	0.311 (1.479)	0.315 (1.496)	0.409 (1.691)c	0.410 (1.696)c	-0.538 (0.988)	-
IPT_{-1}	0.783 (1.111)	0.654 (1.162)	1.655 (1.972)b	1.656 (1.999) b	-0.011 (0.014)	-
FDI_{-1}	-0.120 (0.999)	-	-	-	-	-
F (df)	71.40 (43, 100)a	83.14 (37, 106)a	80.16 (35, 80)a	93.68 (30, 85)a	11.32 (13, 14)a	20.64 (9, 18)a
Adj. R^2	0.955	0.955	0.960	0.960	0.833	0.868
LM	184.4a	195.24a	152.51a	158.82a	8.67a	15.74a
H	24.00a	20.45a	22.03a	20.39a	NA	26.19a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 9.6: Export Equation - Chemical Products

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.003 (0.357)	-	0.005 (0.545)	-	0.134 (0.591)	-
$CAPM_{-1}$	0.108 (0.307)	-	0.190 (0.418)	-	0.144 (0.356)	-
S	0.001 (3.711)a	0.001 (3.654)a	0.001 (3.161)a	0.001 (3.216) a	0.001 (2.273)b	0.001 (2.512)a
S^2	-0.127E-05 (3.677)a	-0.120E-05 (3.711)a	-0.190E-05 (3.047)a	-0.188 (3.068) a	-0.130E-05 (1.944)b	-0.135E-05 (2.123)b
AD_{-1}	0.351 (0.466)	-	0.527 (0.607)	-	-1.832 (1.396)	-1.709 (1.303)
R_{-1}	0.027 (0.047)	-	-0.198 (0.318)	-	4.868 (2.113)b	4.928 (2.138)b
IPT_{-1}	0.855 (1.423)	0.872 (1.466)	0.600 (1.076)	-	24.626 (1.876)c	24.652 (1.886)c
FDI_{-1}	-0.005 (0.334)	-	-	-	-	-
F (df)	37.03 (53, 130)a	42.36 (48, 135)a	27.96 (37, 86)a	33.97 (32, 91)a	54.67 (21, 38)a	63.35 (19, 40)a
Adj. R^2	0.913	0.916	0.890	0.896	0.950	0.953
LM	174.7a	214.39a	122.07a	145.63 a	6.95a	67.14a
H	40.78a	29.58a	28.51a	22.66a	60.65a	36.78a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

Table 9.7: Export Equation – Automobile

Indep. Var	All (1)	All (1.1)	LCE (2)	LCE (2.1)	MNE (3)	MNE (3.1)
CAPI	0.004 (0.170)	-	-0.014 (0.510)	-	0.247 (2.375)b	0.271 (2.530) a
$CAPM_{-1}$	0.067 (1.390)	0.071 (1.752)c	0.041 (0.837)	-	2.007 (2.651)a	2.011 (2.776) a
S	0.958E-04 (3.721)a	0.967E-04 (3.835)a	0.109E-03 (3.615)a	0.115E-03 (3.996)a	0.501E-04 (0.408)	-
S^2	-0.132E-07 (3.604)a	-0.133E-07 (3.659)a	0.148E-07 (3.485)a	-0.157E-07 (3.820)a	0.397E-07 (0.575)	-
AD_{-1}	1.294 (1.772)c	1.483 (2.007)b	0.830 (0.838)	-	3.343 (3.184)a	3.422 (3.242) a
R_{-1}	0.533 (1.946)b	0.532 (2.032)b	0.503 (1.730)c	0.539 (1.958)b	1.643 (1.354)	-
IPT_{-1}	-0.183 (0.458)	-	-0.040 (0.095)	-	-0.715 (0.448)	-
FDI_{-1}	-0.032 (1.028)	-	-	-	-	-
F (df)	8.31 (49, 118)a	8.95 (46, 121)a	8.82 (41, 98)a	10.00 (37, 102)a	3.46 (13, 14)a	4.74 (9, 18)a
Adj. R^2	0.682	0.687	0.698	0.705	0.543	0.555
LM	102.2a	103.39a	87.84a	102.32a	0.33	6.30a
H	33.41a	33.19a	23.20a	22.24a	18.24b	22.33a

Note: The figures in parentheses are heteroscedasticity corrected (White, 1980) t-values. The alphabets a, b and c indicate significance levels at less than 1%, 5% and 10% respectively. The constant terms are suppressed to save the space.

CHAPTER 10

SUMMARY AND CONCLUSIONS

10.1 THE MAIN FINDINGS

The objective of the present study was to find out the major determinants of R&D, profitability and exporting of Indian private corporate firms in select technology intensive industries in the changed economic atmosphere. Specifically the concern was to assess the relationship between internal finance and R&D, the relationship between R&D and profitability and the relationship between R&D and exporting. Moreover, the objective was to assess all these aspects for local firms and the subsidiaries of the MNEs separately. The main conclusion that emerges from the present study is that, in general, firm level determinants of R&D, profitability and exporting varied across different industries and groups. This supports the hypothesis that LCEs and MNEs are altogether two different strategic groups. The main findings of the study may be summarized as follows:

1. In some of the industries (such as machinery, pharmaceutical and automobile) retained earnings provides significant explanation for subsequent R&D intensity for the MNEs. This relationship is also found to hold for the LCEs in the chemical industry. The prior cumulative depreciation reserves positively affect R&D intensity in automobile industry for the MNEs and in machinery and chemical industries for the LCEs. The prior debt-equity ratio is found to be negatively associated with R&D

intensity for the LCEs in the pharmaceutical, chemical and chemical products industries. It has similar effect in case of electrical, automobile, machinery industries for the MNEs. On other hand, debt-equity ratio is positively associated with subsequent R&D efforts in electrical industry for the LCEs and in pharmaceutical and chemical industries for the MNEs.

2. In some of the industries (machinery and pharmaceutical) R&D intensity positively and significantly explains the profitability of LCEs. The same is true for MNEs in the chemical industry. Prior technology import intensity influences profitability of the LCEs positively only in the automobile industry. It has similar effect for the MNEs in the pharmaceutical industry.

3. Prior R&D intensity provides an important explanation for export intensity in pharmaceutical industry for both LCEs and MNEs. It is also important for LCEs in chemical and automobile industries and for MNEs in chemical products industry. Technology import is important for LCEs in chemical and machinery industries. For MNEs it is found to be positively significant in chemical products industry.

4. In most of the industries profitability is found to increase with firm size and decrease with its square term. In contrast, R&D decreases with firm size and increases with its non-linear term. It is the big firms that are able to export. In most of the industries profitability increases while R&D decreased with sales growth.

5. With few exceptions, import pressure adversely affects price-cost margins of the firms, which in turn compels firms to invest in R&D to counter the threats arising from imports.

6. With some exceptions, the FDI spurs R&D of the Indian firms.

7. Technology imports shows positive association with R&D for LCEs in the pharmaceutical industry and for MNEs in the chemical products industry. It is negatively related to R&D in the chemical products and automobile industries for MNEs.

10.2 THE POLICY IMPLICATIONS

1. The LCEs seem to rely more on internal finances for their innovative efforts. While MNEs are able generate resources from internal as well as external sources. This implies that the R&D investments by the MNEs are more strategic rather than binding by the internal resources. Given the highly developed venture capital markets in western developed countries and gigantic size of the MNEs in terms of internal funds, the local firms (except few) would not be able to match with MNEs in terms of R&D investment and hence they would not be able to compete them, particularly when non-price mode of competition (like R&D) is becoming predominant. Thus the Indian policy regime should be proactive in the emergence of venture capital markets in India.

2. In general FDI shows a positive influence upon domestic R&D efforts and negative impact on profitability. Further, import pressure adversely affects price-cost margins of the firms, which in turn compels firms to invest in R&D to counter the threats arising from imports. This implies that competition arising out of FDI and liberal imports may provide for additional means to the regulating authorities to discipline noncompetitive domestic market and induce innovative efforts among the Indian firms. This makes an absolute case for highly liberal FDI and import policies by the Indian Government.

3. The imported technology does have any significant impact upon the in-house innovative efforts of the firms. This again implies that

competitive policy regimes are more important for innovative efforts rather than encouraging for secondary core technology development.

10.3 SCOPE FOR FURTHER RESEARCH

In this study we have considered only some of the important firm level determinants because of the data constraints. One of the most important variables that had been omitted was the market valuation of the firms. The profitability as a measure of benefits to R&D comes through a lag process. On the other hand, the changes in the stock market value of a firm should reflect the expected discounted present value of the firm's entire uncertain net cash flow stream. Thus any event that causes the market to re-evaluate the accumulated output of R&D efforts of the firm is likely to get reflected in full effect in the stock market immediately. In this sense stock market valuation is as a better indicator of profitability than accounting based measures of profitability because of former having fewer accounting biases than later and also captures long-run effects.

Further the present study though encouraging but may not be called conclusive as the data covers only few years of the liberalized policy regime. The data for some more years seems to be inevitable to confirm the present results.

In most of the cases, individual specific constants appeared significant, which points out that some researches are required at the micro level (like case studies) to reach near to the truths of the industry.

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